MEMOIRS

OF THE

NATIONAL MUSEUM OF VICTORIA

MELBOURNE

(World list abbrev. Mem. Nat. Mus. Vict.)

No. 21

Issued 6th August, 1957

C. W. BRAZENOR, ACTING DIRECTOR

PUBLISHED BY ORDER OF THE TRUSTEES

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CONTENTS

REVISION OF THE GENUS STIGMACROS FOREL.

J. J. McAreavey, S.J.

This genus, which appears to be confined to Australia, is widely distributed throughout the country. Even in those States where little collecting has been done, many interesting species have been taken.

In general the species resemble very small *Polyrhachis* in appearance. When it became necessary to divide the genus *Stigmacros* into subgenera, the resemblance between these and some of the subgenera of *Polyrhachis* suggested names for the new subgenera. When more species and information about them are available it may be necessary to raise the subgenera to genera.

In the case of the majority of previously described species the types could not be traced, and so specimens identified with the aid of the original descriptions, have been used to make a re-description. No specimens fitting the descriptions of *Stigmacros medioreticulata* Viehmeyer could be found, so Viehmeyer's description in German has been given. It is not easy to determine from this description to which subgenus this species should belong, but since it seems to resemble species of the *Australis* group, it has been placed, in this revision, under the subgenera *Cyrtostigmacros.* All holotypes of new species described in this paper, unless otherwise mentioned, are in the collections of the National Museum of Victoria.

Subfamily FORMICINAE Lepelietier, 1863.

Tribe PLAGIOLEPIDINI Forel, 1893.

Genus STIGMACROS Forel, 1905.

Acantholepis subgenus Stigmacros Forel, Ann. Soc. Ent. Belg. 49, p.179, 1905 ☿ ♀ ♂

Acantholepis subgenus Acrostigma Forel, Rev. Suisse Zool. 10 p.477, 1902 ☿ ♀ ♂

Stigmacros Emery, Genera Insect. Fasc, 183, p.34, 1925 ☿ ♀ ♂

Worker. 2 mm.-4 mm. monomorphic. Maxillary palpi six-segmented. Labial palpi four-segmented. Mandibles triangular with four or five small sharp teeth. Clypeus feebly produced, convex, sometimes carinated. Frontal area semi-circular, usually clearly defined. Frontal carinae short, parallel or slightly diverging, flattened above, leaving the insertions of the scapes exposed. There are no ocelli. Eyes moderately large, flat or feebly convex, placed near the centre of the sides. Antennae eleven-segmented, the scapes inserted close to

the clypeal suture, apical segments of funiculus slightly enlarged. The thorax is short with the pronotum much broader than the rest of the thorax, with or without a distinct metanotum. In these species with a raised metanotum there are two raised spiracular tubercles, close to the mesometanotal suture. The suture before the epinotum is very distinct and often very deep. The posterior corners of the epinotum either produced as long spines or as short spines, or again not produced but abrupt and sharp edged. About the upper third of the declivity of the epinotum on each side is a spiracular tooth which in some cases is very long. In profile the dorsum of the thorax is either arched or straight and margined. The node varies with the subgenera, being either scale-like and unarmed, the upper surface entire, or notched, or again moderately stout with long curved spines on the upper surface and smaller spines on the sides. Gaster often truncated in front, oval, moderately large. Legs slender or robust, moderately long, anterior pair with pectinate spurs, middle and posterior pairs with small spurs. Claws simple.

Female. Similar to worker and in some subgenera only slightly larger. Antennae eleven-segmented, scape shorter. Eyes larger and more convex, the ocelli clear and distinct. Pronotum short and from above is concealed by the mesonotum which is large and has the parapsidal furrows impressed. All thoracic sutures deeply impressed. Scutellum is large and there is a broad suture between it and the epinotum. Epinotum much broader than long with posterior corners rounded. The stigma-bearing spines on the declivity are short and broader than those of worker. Node similar to that of worker. Gaster very large in some cases. Wings clear with venation brown, rather short with one cubital and one small closed discoidal cell.

Male.—Usually about the size of the worker. Head small with sides very convex. Mandibles narrow, eyes very large and hemispherical, occupying most of the side of the head. Ocelli large, hemispherical placed near the occipital border. Antennae twelve segmented, scapes moderately long. Thorax similar to that of female but the epinotum is rarely armed. Node unarmed even in the case of those species whose workers have the node armed with long spines. Genitalia exposed.

Pupae. Always enclosed in cocoons.

Key to the subgenera. Plate 1. Figs. 1–18.

1. Upper border of the node unarmed 2
—. Upper border of the node armed with two rather long, almost horizontal spines directed backwards .. .. *Hagiostigmacros* Subgenus nov.
2. Dorsum of pronotum and mesonotum convex 3
—. Dorsum of pronotum and mesonotum not convex but straight and horizontal .. .. *Campostigmacros* Subgenus nov.
3. Declivity of epinotum armed on each side with a small tooth directed backwards 4
—. Declivity of epinotum unarmed .. *Pseudostigmacros* Subgenus nov.
4. Metanotum present and distinct 5
—. Metanotum not present .. .. *Stigmacros* sen. stricto
5. Spiracular tubercles present on each side of metanotum .. .. *Cyrtostigmacros* Subgenus nov.
—. Spiracular tubercles not present on metanotum .. .. *Chariostigmacros* Subgenus nov.

STIGMACROS (STIGMACROS) *sensu stricto* Forel.

Species usually smaller than those of other subgenera. The pronotum convex and often forms a single strong convexity with the mesonotum. The suture between mesonotum and epinotum is very distinct but not deep so that from the side view the dorsum of the epinotum seems so close to the mesonotum that it rises abruptly from it. Epinotum armed with small spines; node with or without tiny lateral teeth.

SUBGENOTYPE *Acantholepis (Acrostigma) froggatti* Forel.

Key to species.

1. Upper border of the node viewed from behind entire 2
—. Upper border of node not entire but concave 7

2. Dorsum of epinotum half as long as the declivity 3
—. Dorsum of epinotum not as long as half declivity; Yellowish red. Smooth and shining, sides of mesonotum microscopically reticulate. Length 1·9-2·4 mm. . . . . *froggatti* Forel

3. Node in profile is sharp pointed above 4
—. Node in profile not sharp pointed above but blunted 6

4. Scape of antennae extends beyond occiput by quarter of its length; Reddish yellow. Smooth and shining, sides of mesonotum and epinotum striate. Length 3·3·2 mm. . . . . *wilsoni* sp. nov.
—. Scape of antennae extends beyond occiput by less than a quarter of its length 5

5. Eyes placed at middle of sides of head. Rich yellow. Smooth and shining, sides of head and gaster faintly shagreened. Length 1·5-1·7 mm. . . . . *acuta* sp. nov.
—. Eyes not placed at middle but slightly behind middle. Rich brownish red with vague dark bands on gaster. Smooth and shining with sides of mesonotum and epinotum striate transversely. Length 2 mm. . . . . *rufa* sp. nov.

6. Scape of antennae extends beyond occiput by third of its length. Reddish yellow: Smooth and shining. Length 2-2·2 mm. . . . . *brevispina* sp. nov.
—. Scape of antennae extends beyond occiput by less than a third of its length. Dark chestnut brown. Smooth and shining, sides of mesonotum and epinotum faintly striate transversely. Length 2·1-2·4 mm. . . . . *impressa* sp. nov.

7. Frontal carinae diverging behind 8
—. Frontal carinae not diverging but parallel. Brownish yellow, gaster infuscated. Smooth and shining with faint traces of reticulation on head and thorax. Length 2·8-3·2 mm. . . . . *rectangularis* sp.nov.

8. Node with tiny lateral teeth at base 9
—. Node with no trace of lateral teeth. Reddish yellow with gaster reddish brown. Smooth and shining with faint traces of reticulation on epinotum node and sides of head. Length 3·5-4 mm. . . *bosii* Forel

9. Scape extends beyond occiput by a fifth of its length. Yellow. Entirely smooth and shining. Length 1·4-1·7 mm. . . . . *pusilla* sp. nov.
—. Scape entends beyond occiput by less than fifth of it length. Yellowish with gaster dark reddish brown. Smooth and shining with gaster feebly shagreened. Length 1·2-1·5 mm. . . . . *minor* sp. nov.

STIGMACROS (*STIGMACROS*) FROGGATTI Forel, figs. 19-24.

Acantholepis (*Acrostigma*) *froggatti Forel,* Rev. Suisse Zool. 10, p.478, 1902 ☿ ♀ ♂

Acantholepis (*Stigmacros*) *froggatti* Forel, Ann. Soc. Ent. Belg. 49, p.179, 1905 ☿ ♀ ♂

Stigmacros froggatti Emery, Gen. Insect. fasc. 183, p.34, 1925 ☿ ♀ ♂

Acantholepis (*Stigmacros*) *fossulata* Viehmeyer Ent. Mitt. Berl. 14, nr.I., p.34, 1925 ☿

Acantholepis (*Stigmacros*) *foreli* Viehmeyer, Ent. Mitt. Berl. 14, nr.I., p.34, 1925 ☿ ♀ ♂

Worker. Length 1·9-2·4 mm. Yellowish red with funiculus brownish red except for the first segment. Some examples are more yellowish, while others have the legs brownish and have also vague brown bands on the segments of the gaster.

Entirely smooth and very shining, the sides of head faintly shagreened and the base of the sides of the mesonotum microscopically reticulate.

Hair yellowish, very sparse and confined to the clypeus and apex of the gaster; pubescence yellowish, fine adpressed, confined to the funiculus.

Head very slightly longer than broad, very slightly broader behind than in front, with convex sides and almost straight occipital border and rounded posterior corners; mandibles sparsely punctate microscopically, furnished with four small teeth; clypeus not carinated, rounded above and with rounded anterior border; frontal area distinct, semicircular; frontal carinae short, diverging slightly behind, flattened above with the insertion of the scapes exposed; scapes extend beyond the occipital border by about one-fifth (Forel, one-quarter) of their length; first segment of the funiculus as long as the three following, second as broad as long, third to fifth broader than long, six and seventh as broad as long, rest longer than broad, apical as long as the two preceding together; eyes flat and placed at the middle of the sides.

Thorax twice as long as broad; pronotum twice as broad as long with convex anterior border and feebly convex sides; promesonotal suture distinct; mesonotum nearly as broad as long, broader in front than behind with feebly convex sides; mesoepinotal suture narrow, rather deep, without metanotum; epinotum twice as broad as long, with sides and posterior border straight and the dorsum feebly concave; the epinotal spines are very small, directed backwards and upwards. In profile the promesonotum is convex with a slight depression at the promesonotal suture; dorsum of the epinotum convex with the posterior angle sharp; the declivity one and a half times as long as the dorsum, and a little above the centre is a small sharp spine directed upwards and backwards.

Node narrow with anterior and posterior borders convex, the upper surface feebly concave in the middle. In profile node scale like with anterior convex face meeting the straight posterior face at a point; on each side about the centre is a small tooth directed outwards. Gaster rather large. Legs short and robust.

Female. Length 4·8 mm. Colour darker with the gaster brownish red.

Smooth and shining.

Head similar to that of worker with the eyes comparatively larger, the ocelli distinct and pearl white, the scapes shorter and reaching as far as the occipital border.

Pronotum short with the sides and the occipital border feebly convex; mesonotum large, slightly broader than long with the parapsidal furrows indicated; scutellum broader than long, broader in front than behind; epinotum very short, more than four times as broad as long, broader in front than behind, concave in front and on the posterior border, and with the sides almost straight making sharp posterior corners, the stigma bearing spines on the declivity broad and similar to those of the worker.

Node from above very short, almost reduced to a line, with spines on each side distinct. Gaster very large. Legs robust.

Male. Length 2·6 mm. Dark reddish brown with head, except for the dark funiculus, and the legs, lighter.

Smooth and shining.

Hair yellowish, very sparse, confined to the front of the head and the apex of gaster. Pubescence yellowish, adpressed, confined to the funiculus and legs.

Head almost circular, as broad as long; mandibles small triangular hardly denticulate; clypeus oval, rounded above with rounded entire anterior border; frontal carinae short, diverging slightly behind, flattened above and leaving the insertions of the scapes exposed; frontal area distinct semicircular; scape rather long, extending beyond the occipital border by a fifth; antennae twelve segmented; first segment of the funiculus as long as the two following, all segments much longer than broad, apical segment as long as the two preceding together; eyes large, hemispherical, placed at the centre of the sides of the head; ocelli near occiput, clear and distinct.

Thorax large, twice as long as broad; pronotum hardly noticeable from above; mesonotum massive, broader than long, with the parapsidal furrows very indistinct; scutelum as broad as long, broader in front than behind; metanotum small and narrow; epinotum short, broader in front than behind, more than three times as broad as long, the posterior border hardly defined. In profile the pronotum is short, almost vertical; mesonotum very convex overhanging the pronotum in front and rather flat on posterior third; scutellum rather flat; metanotum convex; dorsum of epinotum rounded into the convex declivity; epinotal spines hardly noticeable.

Node more than three times as broad as long, anterior border convex, posterior border almost straight. In profile node rather large twice as high as long with anterior and posterior borders feebly convex, and curving inwards at top to meet at a blunt apex. Gaster large. Legs slender.

Type locality. Bong Bong. New South Wales.

Redescribed from co-type worker, co-type male from Bong Bong, N.S.W., and a female from Blundell's Creek, A.C.T. A very large number of specimens from New South Wales were examined, but there is little variation.

Types of Forel's Collection, Museum of Natural History, Geneva.

STIGMACROS (STIGMACROS) *WILSONI* sp. nov. figs. 25-27.

Worker. Length, 3-3·2 mm. Reddish yellow with darker patches on the head and brownish bands on the gaster; tip of the funiculus reddish brown.

Smooth and shining with the sides of the mesonotum and epinotum striate.

Hair yellowish, very sparse, confined to clypeus and apex of gaster.

Head slightly longer than broad, broader behind than in front, with the sides and the occipital border almost straight, posterior corners rounded; mandibles triangular with four sharp reddish teeth; clypeus arched above, anterior border rounded and entire; frontal area semicircular, large, distinct; frontal carinae diverging behind strongly; scape extends beyond the occipital border by a quarter; first segment of the funiculus as long as the three following, second to ninth as broad as long increasing in size, apical as long as the two preceding; eyes moderately large, rather flat, placed at the middle of the sides.

Pronotum twice as broad as long, sides and anterior border convex, the anterior corners rounded; mesonotum longer than broad, nearly twice as broad in front as behind, sides feebly convex; epinotum with dorsum concave broader than long, sides and posterior border almost straight, the posterior angles blunt and without teeth. In profile the promesonotum evenly convex; dorsum of the epinotum feebly convex, raised behind, and almost half as long as the straight declivity; stigma-bearing spines at the upper third of the declivity long, stout, sharp pointed, directed backwards and upwards.

Node elliptical with anterior border more convex than the posterior border, the upper surface entire, not concave. In profile node scale-like, three times as high as long, with anterior face feebly convex, merging into the dorsum which meets the straight posterior face at a point. Legs robust.

Female and *male* unknown.

Collected by F. E. Wilson, Esq.

Material examined. Ten workers which vary slightly in colour and size.

Type locality. Cobunga, Victoria,

STIGMACROS (STIGMACROS) ACUTA sp. nov., figs. 28-30.

Worker. Length 1·5-1·7 mm. Bright reddish yellow with the funiculus and the gaster very slightly darker.

Smooth and shining with traces of punctation on the sides of the head and with the gaster very faintly shagreened.

No hair, but pubescence yellowish, adpressed, confined to the funiculus.

Head very slightly longer than broad, broader behind than in front, sides and occipital border feebly convex, posterior angles rounded; mandibles triangular with four small sharp reddish teeth; clypeus rounded above, anterior border rounded and entire; frontal area large, semicircular indicated only in front and on the sides; frontal carinae diverging behind; scapes extend beyond the occipital border by a seventh; first segment of the funiculus as long as the three following, second to fourth broader than long, fifth to seventh as long as broad, eighth and ninth longer than broad, apical as long as two preceding; eyes rather flat, moderately large, placed at middle of sides.

Pronotum twice as broad as long, sides feebly convex, anterior border convex, anterior angles rounded, pro-mesonotal suture distinct; mesonotum longer than broad, broader in front than behind, sides almost straight; meso-epinotal suture broad and moderately deep, epinotum twice as broad as long, sides and posterior border very feebly concave, posterior angles produced as very small teeth, dorsum concave. In profile pro-mesonotum evenly convex, dorsum of epinotum straight, elevated behind, almost half as long as the straight declivity; stigma bearing spines on declivity very sharp, directed backwards and upwards, and a little longer than the teeth on the end of the dorsum.

Node narrow, anterior border convex, posterior border straight, upper border not concave. In profile node scale-like, higher behind than in front, with straight anterior border merging into the convex dorsum which meets the straight posterior border at a point; about the middle on each side is a small tooth. Legs slender.

Male and *female* unknown.

Collected by J. G. O. Tepper, Esq.

Material examined. Seven workers.

Type locality. Mt. Lofty, South Australia.

STIGMACROS (STIGMACROS) RUFA sp. nov., figs. 31-33.

Worker. Length 2 mm. Rich brownish red with funiculus darker, almost black at apex; gaster with vague brown bands.

Smooth and shining with traces of punctation on the sides of the head gaster very slightly shagreened.

Hair yellowish, sparse, confined to clypeus and tip of gaster; pubescence whitish, adpressed, dense on the funiculus.

Head very slightly longer than broad, broader behind than in front, sides convex, posterior border almost straight, posterior angles rounded mandibles triangular with four sharp teeth of which the apical is longest; clypeus convex above, anterior border rounded and entire; frontal area large, semicircular, posterior border not indicated; frontal carinae diverging considerably behind; scape extends beyond the occipital border by a sixth; first segment of funiculus as long as the four following, second to fourth broader than long, fifth to ninth as broad as long, apical as long as two preceding, eyes moderately large, placed just behind the middle of the sides.

Pronotum twice as broad as long, with sides and anterior border feebly convex, anterior angles rounded; mesonotum longer than broad, broader in front than behind; sides almost straight; mesoepinotal suture deep and wide, epinotum twice as broad as long, slightly broader behind than in front, sides and posterior border almost straight, dorsum strongly concave, posterior corners sharp but not produced as teeth or spines. In profile pro-mesonotum strongly convex, epinotal dorsum straight, elevated behind, posterior angle sharp; dorsum half as long as very feebly concave declivity; at upper third of declivity the stigma-bearing spines are sharp, directed backwards and upwards.

Node elliptical, more than three times as broad as long, with convex anterior and posterior borders, dorsum feebly concave. In profile three times as high as long, narrowed at the top, anterior straight border merging into convex dorsum which meets straight posterior border at a point; small blunt teeth at middle of each side. Legs robust.

Male and *female* unknown.

Collected by J. Clark, Esq.

Material examined. Six workers.

Type locality. Kallista, Victoria.

STIGMACROS (STIGMACROS) BREVISPINA sp. nov., figs. 34-36.

Worker. Length 2-2·2 mm. Reddish yellow with the funiculus darker.

Smooth and shining with a few faint striae on the sides of thorax.

Hair yellowish, sparse, confined to the clypeus and apex of gaster.

Pubescence yellowish, adpressed, confined to funiculus.

Head very slightly longer than broad, slightly broader behind than in front, sides convex, occipital border almost straight, posterior angles rounded; mandibles with four teeth; clypeus not carinated, rounded above, with rounded entire anterior border; frontal area distinct, semicircular; frontal carinae diverging rather strongly behind; scapes extend beyond the occipital border by almost a third of their length; first segment as long as the three following, second to fifth broader than long, sixth to eighth as broad as long, ninth longer than broad, apical as long as the two preceding; eyes at the middle of the sides of the head, rather flat.

Thorax twice as long as broad; pronotum twice as broad as long, with convex sides and anterior border, anterior corners rounded; mesonotum distinctly longer than broad, broader in front than behind with almost straight sides; meso-epinotal suture deep and broad, without stigmata; epinotum twice as broad as long, deeply concave on dorsum, broader behind than in front, sides feebly convex, posterior border almost straight, the posterior corners hardly toothed. In profile pro-mesonotum slightly convex, dorsum of epinotum almost straight, half as long as the almost straight declivity, with which it forms almost a right angle; the stigma bearing spines about the upper third are directed upwards and backwards.

Node oval, three times as broad as long, with almost straight anterior and posterior borders and rounded corners, upper surface not concave. In profile node scale-like with anterior border feebly convex, posterior border almost straight, the short dorsum very feebly rounded. There are tiny spines on the sides of node. Legs slender.

Male and *Female* unknown.

Collected by F. E. Wilson, Esq.

Material examined. Sixteen workers.

Type locality. Bogong Plains, Victoria.

STIGMACROS (STIGMACROS) IMPRESSA sp. nov., figs. 37-39.

Worker. Length 2·1-2·4 mm. Dark chestnut brown, front of head slightly lighter, gaster darker, legs antennae more reddish brown.

Smooth and shining with traces of shallow punctures near the posterior corners of the head, sides of mesonotum and epinotum faintly striate transversely.

Hair yellowish, erect, confined to clypeus and apex of gaster, pubescence adpressed, yellowish confined to funiculus and tarsi.

Head slightly longer than broad, slightly broader behind than in front, sides feebly convex, occipital border straight, posterior corners rounded; mandibles with four teeth; clypeus rounded above, anterior border rounded and entire; frontal area large, semicircular, very distinct; frontal carinae short, diverging rather strongly behind; scape extends beyond the occipital border by a fifth of

its length; first segment as long as the three following, second to fifth broader than long, sixth and seventh as broad as long, rest longer than broad, apical as long as the two preceding; eyes moderately large, placed at middle of sides of head.

Pronotum more than twice as broad as long, sides and anterior border convex, anterior angles rounded, mesonotum longer than broad, broader in front than behind, sides feebly convex; meso-epinotal suture deep and wide; epinotum broader than long, very slightly broader behind than in front, sides straight, posterior border convex, the dorsum very concave posterior corners angular but without teeth. In profile pro-mesonotum convex, epinotal dorsum straight, elevated behind, and half as long as the declivity which is straight: stigma bearing spines on declivity long as broad at base sharp, directed upwards and backwards.

Node much broader than long, anterior border feebly convex, posterior border straight, corners sharp. In profile three times as high as long, anterior border feebly convex, dorsum bluntly rounded, meeting the straight posterior border at a point; on each side a tiny tooth; legs slender.

Male and *female* unknown.

Collected by J. Clark, Esq.

Material examined. Ten workers.

Type locality. Taggerty, Victoria.

STIGMACROS (STIGMACROS) RECTANGULARIS sp. nov., figs. 40-44.

Worker. Length 2·8-3·2 mm. Brownish yellow, head more reddish than thorax, gaster infuscated.

Smooth and shining with faint traces of reticulation on head and thorax. sides of epinotum and mesonotum microscopically reticulate.

Hair yellow, confined to mandibles, clypeus and apex of gaster; pubescence fine adpressed, silvery, confined to funiculus.

Head rectangular, one-quarter longer than broad, with sides almost straight, occipital border feebly concave, posterior corners rounded, mandibles with five small irregular teeth; clypeus rounded above, not carinated, anterior border rounded and entire; frontal area semicircular, clearly indicated; frontal carinae, short, almost parallel, flattened above exposing the insertions of scapes; scape extends beyond the occipital border by a fifth; first segment of funiculus almost as long as the three following, second longer than the third, third to fifth as broad as long, rest longer than broad, apical as long as the two preceding; eyes large, flat, placed just behind the middle of the sides.

Pronotum twice as broad as long, anterior border convex, sides almost straight; mesonotum longer than broad, broader in front than behind, sides almost straight, posterior border produced back over the meso-epinotal suture as rather blunt corners directed backwards; epinotum slightly broader than long, slightly concave on dorsum, sides almost straight, posterior border feebly concave, posterior corners rounded not toothed. In profile pro-mesonotum forms an even convexity with a marked depression at the pro-mesonotal suture; dorsum of the epinotum almost straight, raised behind, forming a sharp angle with the almost straight declivity which is more than twice as long as the dorsum; epinotal spines are placed at the upper third, are very sharp, directed backwards and slightly upwards.

Node very narrow, almost reduced to a line, feebly convex in front with posterior border straight. In profile scale like, four times as high as long with anterior border convex meeting the straight posterior border at a point. Legs rather slender.

Male. Length 1·7 mm. Yellowish brown, mottled with small irregular lighter patches; there is a very small dark patch around the ocelli.

Smooth or very faintly shagreened.

Whole body is covered with short adpressed yellowish pubescence which in no way hides the sculpture, and is denser on the funiculus legs and last segment of gaster.

Head slightly longer than broad, sides very convex, occipital border short and straight; mandibles narrow and appear to be toothless; clypeus rounded in front, frontal area small, semicircular but distinct frontal carinae very short, very slightly diverging behind, insertions of scapes exposed; scapes fail to reach the occipital border by their thickness first segment of funiciulus as long as the three following, second slightly longer than the third, third to eighth as broad as long, rest longer than broad, apical as long as two preceding together; eyes hemisperical, placed just behind the middle of the sides and occupying the greater part of the sides; ocelli prominent, large and distinct, the posterior forming strong angles on occipital border.

Thorax large and robust, about a third longer than broad; pronotum from above is completely hidden by the overhanging mesonotum; mesonotum large, a quarter broader than long, parapsidal furrows not impressed; scutellum large rounded above, broader behind than in front; epinotum more than twice as broad as long, narrowed behind with straight sides and anterior and posterior borders slightly concave; there are no spines on the spinotum. In profile pronotum is short and almost vertical; mesonotum vertical in front and rounded into the almost straight dorsum of the thorax.

Node small, almost reduced to a straight line, the posterior border slightly convex, and anterior border almost straight. In profile node is scale-like, low, three times as high as long, with anterior border straight meeting the posterior feebly convex border at a sharp point. Gaster longer than broad with a rather pointed apex. Genitalia exposed. Legs slender.

Female unknown.

Collected by J. Clark, Esq.

Material examined. A very large number of workers and males.

Type locality. Mundaring, Western Australia.

STIGMACROS (STIGMACROS) PUSILLA sp. nov., figs. 45-47.

Worker. Length 1·4-1·7 mm. Yellow with legs paler and apical half of funiculus dull brown.

Entirely smooth and shining.

No hair but pubescence yellowish, adpressed and confined to the funiculus and mandibles.

Head slightly longer than broad, slightly broader behind than in front, sides and occipital border very feebly convex, posterior corners rounded; mandibles triangular with four or five small reddish teeth; clypeus rather large, arched above, not carinated, anterior border rounded and entire; frontal area semicircular, indicated only in front and on the sides; frontal carinae diverging very

slightly behind, almost straight; scape extends beyond the occipital border by a fifth of its length; first segment of funiculus as long as three following, second longer than third, second to eighth broader than long, ninth longer than broad, apical almost as long as three preceding together; eyes moderately large, placed at the middle of the sides.

Pronotum twice as broad as long, with sides and anterior border feebly convex, anterior corners rounded; mesonotum longer than broad, broader in front than behind, sides almost straight; meso-epinotal suture deep and wide; epinotum twice as broad as long, broader in front than behind, sides straight, posterior border very slightly concave, dorsum concave, posterior angles bluntly toothed. In profile pro-mesonotum evenly and feebly convex with meso-epinotal suture deep; dorsum of epinotum almost straight, elevated behind, the posterior corner sharp; dorsum of epinotum less than a third of the feebly concave declivity; at upper third are the sharp stigma bearing spines, triangular and a little longer than broad at the base, directed backwards and upwards.

Node reduced almost to a transverse line, slight concave in the middle. In profile very slender, the almost straight anterior and posterior borders meeting at a sharp point, small teeth on the sides at middle of node. Gaster large. Legs robust.

Female and *male* unknown.

Collected by Dr. W. M. Wheeler.

Material examined. Twenty-one workers.

Type locality. Canberra, Australian Capital Territory.

STIGMACROS (STIGMACROS) MINOR sp. nov., figs. 48-50.

Worker. Length 1·2-1·5 mm. Rich light-reddish yellow, thorax, node, legs and antennae yellow, apex of funiculus reddish brown, gaster dark-reddish brown.

Smooth and shining with gaster feebly shagreened.

Hair yellow confined to clypeus and apex of gaster; pubescence yellowish, adpressed, confined to funiculus.

Head slightly longer than broad, very slightly broader behind than in front, sides feebly convex, occipital border almost straight; mandibles triangular with four small teeth; clypeus rounded above, not carinated, anterior border rounded and entire; frontal area large, semicircular, indistinctly marked; frontal carinae short, diverging behind; scape extends beyond occipital border by its thickness; first segment of funiculus as long as the three following, second longer than third, second to fifth broader than long, sixth to ninth broad as long, apical as long as two preceding together, all segments increase in size towards apex; eyes moderately large, convex, placed at the centre of the sides.

Pronotum almost three times as broad as long, broader in front than behind, anterior border feebly convex, sides almost straight, anterior angles rather abrupt; mesonotum longer than broad, broader in front than behind, sides almost straight; meso-epinotal suture deep; epinotum almost three times as broad as long, very slightly broader behind than in front, sides straight, posterior border very feebly concave, posterior angles blunt, dorsum deeply concave in middle. In profile pronotum convex in front but rather flattened behind; mesonotum feebly convex; epinotal dorsum straight, elevated behind and produced to a rather sharp spine, almost half the length of the straight declivity; epinotal spines sharp, directed upwards and backwards.

Node narrow, elliptical, with anterior border deeply convex, posterior border straight, angles blunt, dorsum deeply concave in middle. In profile thorn-like with anterior border feebly convex meeting the feebly concave posterior border at a sharp point, the curved anterior face can be seen from the side; small spines at middle of each side. Legs slender.

Male and *female* unknown.

Collected by H. Hacker, Esq.

Material examined. Three workers which vary slightly in colour.

Type locality. Brisbane, Queensland.

STIGMACROS (STIGMACROS) BOSII Forel, figs. 51-54.

Acantholepis (Acrostigma) bosii Forel, Rev. Suisse Zool. 10, p.477, 1902 ☿ ♀

Acantholepis (Stigmacros) bosii Forel, Ann. Soc. Ent. Belg. 49, p.179, 1905 ☿ ♀

Stigmacros bosii Emery, Genera Insect. fasc. 183, p.34, 1905 ☿ ♀

Worker. Length 3·5-4 mm. Rich yellow with antennae yellowish brown, the funiculus being slightly darker, tibiae and tarsi darker yellow than body but femora lighter, gaster more reddish brown with margins of gastric segments yellowish.

Smooth and shining with faint traces of microscopic reticulation, which is more noticeable on epinotum, node and sides of head.

Hair yellowish confined to mandibles, anterior border of cypeus and apex of gaster; pubescence silvery, very fine, adpressed, confined to funiculus and tarsi.

Head almost one-quarter longer than broad, slightly broader behind than in front, sides convex, occipital border almost straight, posterior corners rounded; mandibles narrow with four small teeth of which the apical is twice as long as the others; clypeus rather large convex above, not carinated, anterior border rounded and entire; frontal area semicircular, clearly indicated, frontal carinae short, diverging behind; scape extends beyond the occipital border by a sixth of its length. First segment of funiculus as long as three following, second slightly longer than third, third to sixth as broad as long, rest longer than broad, apical as long as two preceding; eyes moderately large, flat, placed just behind the middle of sides.

Pronotum twice as broad as long, anterior border and sides strongly convex, mesonotum slightly longer than broad, slightly broader in front than behind, sides straight; mesoepinotal suture wide and deep; epinotum nearly twice as broad as long, with sides and posterior border almost straight. In profile the pro-mesonotum evenly convex with a slight depression at the pro-mesonotal suture; dorsum of epinotum feebly convex, and half as long as the straight declivity; the epinotal spines very short directed backwards, and slightly outwards.

Node elliptical, three times as broad as long, slightly concave on dorsum. In profile node three times as high as long, anterior border feebly convex, rounded into the dorsum, the posterior border almost straight. There is no trace of lateral teeth. Legs short and robust.

Female. Length 5 mm. Colour darker, more reddish brown, but sculpture and pilosity as in worker.

Head as in worker but relatively shorter; the teeth of the mandibles of equal length; frontal area not so clearly outlined; the ocelli are yellowish, small but distinct.

Thorax one and a fifth times longer than broad; pronotum hardly noticeable from above, is very much broader than long; mesonotum slightly broader than long, the parapsidal furrows distinct; scutellum twice as broad as long, broader in front than behind, convex in front, sides and posterior border almost straight; between scutellum and epinotum is a very wide deep suture; epinotum short, three times as broad as long, with sides and posterior border straight; spines on the declivity sharper than those of worker. In profile pronotum almost vertical; mesonotum strongly convex on anterior third; rest of dorsum of thorax almost straight; epinotal dorsum almost a third as long as the feebly concave declivity; rest as in worker.

Node in profile has the anterior face very feebly convex, the posterior face straight on lower three-quarters but the upper quarter is abruptly turned inwards to meet the anterior border in a sharp point.

Male unknown.

Material examined. A very large number of workers and females collected by Dr. W. M. Wheeler at Creel Mt. near Mt. Koscuisko, New South Wales.

Type locality. Queanbeyan, New South Wales.

Types in Forel's Collection, Museum of Natural History, Geneva.

Redescription from specimens from the type locality.

STIGMACROS (HAGIOSTIGMACROS) Subgenus novum.

The suture between the mesonotum and epinotum is broad and deep, but there is no raised metanotum nor spiracular tubercles. The posterior angles of the epinotum are produced backwards in two long sharp spines. About the middle of the declivity of the epinotum on each side is a long sharp horizontal spine. The upper border of the node carries on each side a rather long horizontal tooth directed backwards. About the middle of each side of the node is a rather long spine directed outwards.

Subgenotype *Stigmacros barratti* Santschi.

Key to species.

1. Spines on dorsum of epinotum as long as those on the declivity . . . . . *spinosa* sp. nov.
—. Spines on dorsum of epinotum not as long as those on declivity . . 2
2. Sculpture of head and thorax striate . . . . . *barratti* Santschi
—. Sculpture of head and thorax not striate but reticulate punctate . . . . . *punctatissima* sp. nov.

STIGMACROS (HAGIOSTIGMACROS) SPINOSA, sp. nov., figs. 55-59.

Worker. Length 2·8-3·1 mm. Rich reddish yellow, head, antennae and legs paler, eyes black.

Head finely longitudinally striate with a few fine circular striae around the insertions of scapes, back of head finely and densely reticulate, mandibles and clypeus smooth; pronotum and mesonotum very finely longitudinally striate; epinotum and node transversely and more strongly striate-rugose, declivity transversely striate, sides of thorax finely transversely striate; gaster smooth and shining.

Hair yellow, long, erect confined to clypeus and gaster; pubescence yellowish, adpressed, fine, confined to funiculus.

Head one-sixth longer than broad, sides almost straight, occipital border straight, corners rounded; mandibles with four small sharp teeth; clypeus not carinated, anterior border rounded; frontal area distinct semicircular; frontal carinae short, almost straight; scapes extend beyond the occipital border by a quarter, first segment as long as two following, second to fifth almost equal, slightly longer than broad, rest nearly twice as long as broad, apical as long as the preceding two; eyes very large, convex, placed just behind the middle of the sides.

Pronotum slightly more than twice as broad as long, sides and front convex, corners rounded; pro-mesonotal suture deep; mesonotum slightly broader than long, sides margined, slightly convex, metanotum not defined but at the posterior border of mesonotum on each side is a small tooth, directed upwards and slightly outwards; meso-epinotal suture very deep; epinotum semicircular, broader than long, broader behind than in front, sides straight and produced behind in two very long narrow straight spines which are three-quarters as long as their interval, posterior border between the spines feebly concave; these spines conceal the spines on the declivity. In profile pronotum convex; mesonotum almost straight and horizontal, the stigma-bearing spines as long as broad at base, and directed backwards so that they overhang the meta-epinotal suture which is as deep as wide; dorsum of epinotum flat and horizontal, half as long as the straight declivity; spines on posterior border of dorsum very straight, sharp and slender; at middle of declivity is a slightly shorter spine on each side, broader but parallel to the upper spines.

Node about three times as broad as long, the corners produced backwards and slightly outwards as long sharp spines. In profile three times as high as long, sides parallel and straight, the upper spines are almost as long as the width of the node, directed backwards and slightly upwards. On each side about the middle is a smaller spine directed outwards and upwards. Gaster large elliptical. Legs long and slender.

Female. Length 4-4·2 mm. Thorax dark-reddish brown, legs, antennae, and gaster lighter-reddish yellow.

Pronotum finely shagreened, mesonotum and scutellum finely longitudinally striate, epinotum finely transversely striate, node shagreened, gaster smooth.

Head as in worker, but with distinct small black ocelli.

Pronotum short, with feebly convex sides and front, angles rounded; mesonotum broader than long, parapsidal furrows hardly impressed; scutellum one and a half times as broad as long, slightly broader in front than behind, it is separated from the spinotum by a broad suture; epinotum three times as broad as long, as broad behind as in front, sides straight, posterior border slightly concave, the posterior corners produced back as two long slender sharp spines; below these about the middle of the declivity are similar spines, which extend back to the same distance.

Node as in worker though the sharp spines on dorsum are smaller. Legs slender.

Male. Unknown.

Collected by J. W. T. Armstrong, Esq.

Type locality. Nyngan, New South Wales.

STIGMACROS (HAGIOSTIGMACROS) BARRATTI Santschi, figs. 60-67.

Stigmacros barratti, Santschi. Bull. Soc. Vaud. Sc. Nat. 56, 221, p.477, 1928 ♀

Worker. Length 3-3·4 mm. Ochraceous to reddish yellow with gaster clearer yellow and often the node is brownish; apical half of funiculus, sometimes whole funiculus black; legs and scapes brownish yellow. There is a black or dark brown band, interrupted in middle, on second segment of gaster and similar smaller bands or patches on the following segments.

Mandibles smooth with a few scattered microscopic punctures; head densely finely rugulose longitudinally, the back of head more reticulate punctate, pronotum very finely, densely rugulose; mesonotum microscopically striate; epinotum finely shagreened; declivity of epinotum very finely transversely striate; node very finely reticulate punctate; sides of pronotum finely transversely striate, sides of meso-epinotum more reticulate punctate with a few fine transverse striae; base of sides of node finely reticulate punctate.

Head a little longer than broad, slightly broader behind than in front, sides and occipital border feebly convex, corners rounded; mandibles narrow with four strong teeth; clypeus feebly carinated, anterior border rounded and produced forwards. Frontal area triangular, as broad as long; frontal carinae diverging behind; scapes extend beyond the occiput by a quarter; first segment as long as the two following, second to fifth equal slightly longer than broad, sixth to eighth longer than broad, ninth as broad as long, apical as long as two preceding; eyes large placed just behind the middle of the sides.

Pronotum twice as broad as long, very slightly impressed in middle, sides and front feebly convex, angles broadly rounded; mesonotum slightly longer than broad, broader in front than behind, sides very feebly convex; meso-epinotal suture deep and wide; epinotum broader in front than behind, dorsum deeply concave, posterior corners produced as two rather long spines, posterior border concave; stigma-bearing spines on declivity are very long, sharp, directed backwards and slightly outwards. In profile pronotum convex in front, more flattened behind; mesonotum higher than pronotum, more convex; epinotum rises abruptly from meso-epinotal suture and is flat, horizontal and half as long as almost straight epinotal declivity; just above middle are the long stigma-bearing spines, four times as long as spines on dorsum.

Node large, elliptical, four times as broad as long, the corners produced backwards to form sharp spines. In profile three times as high as long at base, borders almost straight. On each side about the centre is a moderately large spine directed outwards and slightly upwards. Gaster tapers to a point. Legs robust.

Female. Length 3·8-4 mm. Head and gaster of same colour as that of worker; thorax darker red.

Sculpture and pilosity of worker.

Head similar to that of worker but posterior corners of head more abruptly rounded, giving a more squarish appearance, ocelli distinct.

Pronotum short, partly concealed by mesonotum, sides and front convex; mesonotum very large, almost as long as broad, the parapsidal furrows not indicated; scutellum large, as broad as long, broader in front than behind; there is a deep, broad suture between it and the epinotum; epinotum twice as broad in front as long, nearly twice as broad in front as behind, sides straight and posterior border concave; centre of dorsum deeply concave and sloping into

the declivity, posterior corners with small teeth, declivity visible from above with two long sharp spines placed about the middle of each side, directed outwards and backwards.

Node proportionately smaller than that of worker but of similar shape. Legs robust.

Male. Length 4mm. Head reddish brown, occipital region almost black; thorax except for pronotum very dark reddish brown; pronotum and legs yellowish brown, node dark brown, gaster dark brown with apex yellowish.

Head very finely longitudinally striate, more reticulate towards back; pronotum transversely striate; mesonotum and scutellum longitudinally striate; epinotum irregularly regulose, node smooth except for shallow microscopic punctures on anterior face; sides of meso-epinotum reticulate punctate; gaster smooth.

Head slightly longer than broad, broader behind than in front; sides convex, posterior border almost straight, angles rounded; mandibles with four teeth, apical longest; clypeus feebly carinated, produced to a point in front; frontal area distinct, triangular; frontal carinae short, diverging very slightly; scape extends beyond occiput by a third; antennae of twelve segments, first segment as long as two following, apical as long as two preceding, all segments nearly twice as long as broad; eyes large at middle of sides; ocelli yellowish, small but distinct.

Pronotum short partly concealed by mesonotum, in profile almost vertical; mesonotum slightly broader than long, broader behind than in front, parapsidal furrows indicated; scutellum large broader than long, broader in front than behind, between it and epinotum is deep broad suture; epinotum twice as broad as long, broader in front than behind, sides almost straight posterior border feebly concave, posterior angles hardly toothed, the stigmata on sides of declivity distinct but no teeth or spines.

Node oval, twice as broad as long, anterior and posterior borders feebly convex. In profile dome-shaped, anterior and posterior borders almost straight, dorsum convex. Legs long and slender. Described from a very large number of workers and several males and females taken by J. Clark at Mount William, Victoria.

Type locality. Ringwood, Victoria.

Type. Type worker in Santschi Collection, Basle Museum, Switzerland.

STIGMACROS (HAGIOSTIGMACROS) PUNCTATISSIMA sp. nov., figs. 68-71.

Worker. Length 3-3·3 mm. Uniformly yellowish red, epinotum brownish red, legs and antennae yellow.

Mandibles smooth, clypeus, frontal area and area between the frontal carinae finely longitudinally striate, rest of head, thorax and node densely microscopically reticulate punctate, declivity of epinotum reticulate, gaster very finely longitudinally striate.

Hair yellow confined to front of head and apex of gaster.

Head almost a quarter longer than broad, sides and occipital border straight, posterior corners abruptly rounded; mandibles with two large and three small teeth; clypeus arched above, carinated on anterior half, produced to a blunt point in front, frontal area semicircular, distinct; frontal carinae straight and parallel scapes extend beyond occiput by a fifth; first segment not quite as long as the two following, all segments longer than broad, apical as long as preceding two; eyes large, black, placed just behind the middle of the sides.

Pronotum twice as broad as long, sides and front feebly convex, corners rounded; mesonotum slightly longer than broad, broader in front than behind, sides almost straight, posterior angles slightly elevated; meso-epinotal suture deep; epinotum broad as long, sides straight, posterior corners produced behind as sharp spines directed backwards, the tips curved slightly outwards, dorsum of epinotum concave; on the spinotal declivity are long slender spines extending backwards and slightly upwards. In profile pronotum convex in front, rather flat behind; mesonotum very feebly convex; meso-epinotal suture deep; dorsum of epinotum straight and horizontal, almost as long as the straight declivity; posterior corner overhangs the declivity giving the appearance of a slightly concave declivity; spines at middle sharp and slender, directed backwards.

Node large dorsum deeply concave in centre with upper angles produced slightly backwards as blunt teeth, spines on sides clearly visible from above, slender and sharp. In profile twice as high as long at base, anterior border including teeth on upper border is evenly convex, posterior border almost straight as far as the teeth on upper border. On each side just below the middle is a long slender spine directed outwards and very slightly backwards. Legs rather long and slender.

Male and *female* unknown.

Collected by W. M. Mann, Esq.

Type locality. Leura, New South Wales.

STIGMACROS (CHARIOSTIGMACROS) Subgenus novum.

Pronotum and mesonotum convex. Between the mesonotum and the epinotum is large flat area which is lower than the mesonotum and the epinotum. In the centre of this area is a very narrow raised transverse ridge. The epinotum is armed with small spines directed outwards and slightly backwards. On each side of the node is a rather long spine directed outwards.

Subgenotype *S. Chariostigmacros hirsuta* sp. nov.

STIGMACROS (CHARIOSTIGMACROS) hirsuta sp. nov. figs. 72-75.

Worker. Length 2·5-3 mm. Head dark reddish brown, lighter in front, funiculus brownish, mandibles yellowish; thorax and legs dark brown almost black.

Head smooth; pronotum and mesonotum reticulate punctate, epinotum more striate transversely, sides of thorax densely reticulate punctate.

Hair dark scattered on front of head and gaster; pubescence greyish confined to antennae and legs.

Head longer than broad, broader behind than in front, sides feebly convex, occipital border straight, corners rounded; mandibles with very small blunted teeth; clypeus produced to a point in front, carinated; frontal area semicircular, indicated only in front; scapes extend beyond occiput by third; first segment as long as two following, second to fifth as broad as long, rest longer than broad, apical as long as two preceding; eyes large, convex, placed just behind the middle of sides.

Pronotum short, about three times as broad as long, sides convex, anterior border almost straight, corners abrupt; mesonotum longer than broad, not much smaller behind than in front; between the mesonotum and epinotum is a large flat area lower than mesonotum and epinotum, in the centre of this area is a very narrow raised transverse ridge, stigmata not apparent; epinotum

one-quarter broader than long, sides margined, almost straight, posterior border very feebly concave, corners sharp; spines on declivity slightly longer than broad at base, directed outwards and slightly backwards. In profile pronotum convex, anterior half of mesonotum flat, posterior half depressed and lower than epinotum; in place of metanotum is a narrow ridge rising abruptly from this flat ares; spinotum raised, straight and at right angles to straight declivity which is twice as long as dorsum, posterior corner produced as a small tooth; spines on upper third of declivity stout, directed backwards and upwards.

Node almost reduced to margined line, anterior border convex, posterior border concave, roughly convex on top, spines on sides long and stout. In profile stout, anterior feebly convex border meeting straight posterior border at a point. Legs robust.

Male and *female* unknown.

Collected by Dr. W. M. Wheeler.

Material examined. Nineteen workers.
Type locality. Kuranda, Queensland.

STIGMACROS (PSEUDOSTIGMACROS) Subgenus novum.

Pronotum and mesonotum convex. Between the mesonotum and epinotum is a narrow raised metanotum separated from the other segments by broad sutures. On each side of this metanotum is a small tubercle. The stigmata on the spinotal declivity are very distinct but there are no spines or teeth on the epinotum. The node also is quite unarmed.

Subgenotype *S. Pseudostigmacros inermis* sp. nov.

STIGMACROS (PSEUDOSTIGMACROS) inermis sp. nov., figs. 76-78.

Worker. Length 3-4·8 mm. Head and gaster deep black; thorax, node, legs antennae and mandibles reddish brown.

Head smooth shining; thorax smooth with epinotum very feebly shagreened, sides of mesoepinotum densely longitudinally striate; gaster smooth.

Hair whitish, long erect, scattered plentifully over whole body, legs and antennae; pubescence yellowish, adpressed, confined to funiculus and tarsi.

Head one sixth longer than broad, slightly broader behind than in front, sides feebly convex, occipital border almost straight, corners rounded; mandibles triangular with five teeth; clypeus carinated, rounded in front and entire; frontal area semi-circular, indistinct; frontal carinae, short, almost straight; there is a short frontal groove; scape extends beyond the occiput by half its length; first segment as long as two following, second shorter than third, long as broad, rest twice as long as broad, apical as long as two preceding; eyes placed just behind the middle.

Pronotum twice as broad as long, convex sides and front, corners rounded; mesonotum very slightly broader than long, broader in front than behind, sides feebly convex; meso-metanotal suture indicated by a transverse depression; metanotum elevated, more than twice as broad as long with a moderately distinct tubercle on each side; metaepinotal suture deep and broad; epinotum nearly square, sides straight, posterior border feebly concave; dorsum feebly concave, posterior corners blunt; stigmata on the declivity noticeable but there are no spines. In profile pronotum and mesonotum moderately convex; metanotum humped; dorsum of epinotum almost straight, one-third shorter than the almost straight declivity; no epinotal spines.

Node from above elliptical, about four times as broad as long, borders feebly convex, dorsum feebly convex. In profile large, three times as high as long, feebly convex anterior border, straight posterior border, dorsum rounded; near base on each side an extremely tiny sharp point in place of lateral teeth.

Male and *female* unknown.

Collected by J. W. T. Armstrong, Esq.

Material examined. Eighteen workers of slightly varying sizes.

Type locality. Nyngan, New South Wales.

STIGMACROS (CAMPOSTIGMACROS) Subgenus novum.

The dorsum of the thorax in profile is straight and horizontal, with the pronotum and mesonotum often strongly margined. The suture between the mesonotum and epinotum is deep and wide so that the epinotum forms a very distinct segment of the thorax. There is no raised metanotum and no trace of spiracular tubercles. On each side about the middle of the declivity of the epinotum is a small tooth. Sometimes there are lateral small teeth on the node.

Subgenotype *Acantholepis* (*Stigmacros*) *aemula* Forel.

Key to species.

1. Dorsum of node not concave 2
—. Dorsum of node concave 4

2. Scape extends beyond occiput by more that its thickness .. 3
—. Scape extends beyond occiput by not more than its thickness. Head, thorax, gaster, anterior coxae black, rest yellow. Length 2-2·3mm. . . . . *flavinodis* Clark

3. Eyes placed behind the middle of sides of head. Head reddish brown, pronotum, mesonotum, node, legs, antennae yellowish brown; epinotum and gaster black. Length 2 mm. . . . . *pilosella* Viehmeyer.
—. Eyes placed at centre of side of head. Brown, narrow black margins on meso. and epinotum; legs yellowish brown, mandibles yellow. Length 2 mm. . . . . *marginata* sp. nov.

4. Scape extends beyond the occiput by quarter of its length .. 5
—. Scape extends beyond occiput by less than a quarter 7

5. Dorsum of thorax noticeably sculptured 6
—. Dorsum of throrax not sculptured. Head and gaster black; epinotum dark brown; rest yellow. Length 2-3 mm. . . . . . . *epinotalis* sp. nov.

6. Eyes placed behind middle of sides of head. Black, mandibles, antennae except apical segments, tibiae and tarsi testaceous: Length 2·2-2·6 mm. . . . . *reticulata* Clark.
—. Eyes placed at middle of sides of head. Black, mandibles, legs, antennae yellowish brown. Length 2-3 mm. . . . . *anthracina* sp. nov.

7. Dorsum of thorax noticeably sculptured. 8
—. Dorsum of thorax not noticeably sculptured 9

8. Occipital border feebly concave. Head and gaster dark brown, thorax and node reddish brown, rest reddish yellow. Length 1·7-2 mm. .. *aemula* Forel
—. Occiptal border feebly convex. Head, thorax, node, reddish brown gaster dark brown, rest yellowish brown. Length 2 mm. . . . . . . *stanleyi* sp. nov.

9. Eyes placed at centre of sides of head 10
—. Eyes placed not at centre but slightly behind centre. Very dark reddish brown, mandibles, antennae dull brown. Length 2 mm. . . . . *nitida* sp. nov.

Node with small lateral teeth .. .. N 11
—. Node without small lateral teeth. Head and thorax black, node brownish, gaster amber, rest yellowish. Length 1·8-2 mm. . . . . *elgans* McAreavey

11. Head and thorax shining black, antennae and legs brownish yellow, coxae black. Length 2·2 mm. . . . . *brachytera* sp. nov.
—. Head dark brown, thorax and node reddish brown, rest reddish yellow. Length 2-2·2 mm. . . . . *intacta* Viehmeyer.

STIGMACROS (CAMPOSTIGMACROS) FLAVINODIS Clark, figs. 79-81.

Stigmacros flavinodis Clark Proc. Roy. Soc. Vict. 50, pt.2, p.375, 1938.

Worker. Length 2-2·3 mm. Head, thorax, gaster and anterior coxae black, mandibles, antennae node and legs yellow.

Shining head, mandibles and gaster very finely punctate. Thorax very finely and densely reticulate, anterior face of node finely reticulate.

Hair yellow, long, very sparse, confined to clypeus and apical segments of gaster; pubescence yellow, very short, fine and adpressed throughout.

Head as long as broad, occipital border feebly, sides strongly convex, angles rounded. Mandibles furnished with six large sharp teeth. Clypeus convex above, short, anterior border straight at middle. Frontal area feebly defined, triangular. Frontal carinae short and parallel, antennal insertions exposed. Scapes extend beyond the occipital border by their thickness. First segment of funiculus as long as the two following combined, apical as long as or longer than the two following combined. Eyes large and convex, placed at the middle of the sides. Thorax one-third longer than broad, suture sharply impressed. Pronotum fully twice as broad as long, sides and front feebly convex, angles broadly rounded. Mesonotum one-quarter broader than long, almost twice as broad in front as behind, sides and front convex, posterior border straight, meso-epinotal suture wide and very deep. Epinotum twice as broad as long, broadest behind, sides feebly convex, posterior border feebly concave. In profile dorsum feebly convex, superior border margined, pro-mesonotal suture sharply impressed, meso-epinotal suture very deep and wide, twice as deep as wide, wedge-shaped. Pronotum dropping abruptly in front, concave, dorsum convex. Mesonotum feebly convex, truncated behind, three times longer that the truncate face behind, posterior angle sharply rounded. Epinotum straight, one-third shorter than the declivity, the spine as long as broad at base, posterior border of dorsum bluntly rounded, anterior face dropping at an acute angle, straight. Node scale-like, broad, convex in front, concave behind, angles feebly produced backwards, dorsum entire, in profile slender, anterior face convex, posterior face concave, dorsum sharp, midway between base and apex at each side is a small blunt spine. Gaster one-third longer than broad strongly convex. Legs short and robust.

Male and *Female* unknown.

Collected by J. Clark, Esq.

Material examined. Several specimens from among dead leaves.

Type locality. Reevesby Island, South Australia.

Type. Holotype worker in National Museum, Victoria.

STIGMACROS (CAMPOSTIGMACROS) MARGINATA sp. nov., figs. 82-84.

Worker. Length 2 mm. Brown with narrow black margins on mesonotum and epinotum, legs yellowish brown, mandibles yellow.

Head smooth with occiput faintly reticulate; thorax very finely reticulate.

Head slightly longer than broad, not broader behind than in front, sides deeply convex, occipital border straight, corners rounded; mandibles with four small teeth; clypeus rounded in front not carinated; frontal area semicircular, not distinct; frontal carinae short and parallel; scape extends beyond the occiput by a fifth; first segment as long as two following, second and third as broad as long, rest longer than broad; eyes flat, rather small, placed at middle of sides.

Pronotum twice as broad as long, sides and front almost straight, angles rounded; mesonotum broad as long, not much narrower behind than in front; meso-epinotal suture deep, epinotum one-quarter broader than long, slightly broader behind than in front, sides and posterior borders straight, corners sharp.

In profile pro-mesonotum straight and horizontal; suture deep; epinotum straight, not much shorter than the straight declivity, corner sharp; at upper third a short sharp spine as long as broad at base, directed backwards.

Node very broad, anterior border feebly convex, posterior border straight, corners sharp, dorsum entire. In profile as high as the dorsum of epinotum, anterior slightly convex border meeting the straight posterior border at a point. Legs slender.

Male and *Female* unknown.

Collected by Dr. W. M. Wheeler.

Type locality. Gosford, New South Wales.

STIGMACROS (CAMPOSTIGMACROS) BRACHYTERA sp. nov., figs. 85-88.

Worker. Length 2·2 mm. Black, mandibles, antennae and legs except for black coxae, yellow.

Smooth and shining except for a few scattered microscopic punctures.

Hair yellow on front of head, pubescence whitish, very short, scattered throughout.

Head slightly longer than broad, slightly broader behind than in front, sides strongly convex, occipital border straight, corners rounded; mandibles with four or five small sharp teeth; clypeus not carinated, rather narrow, anterior border rounded, a little flattened at centre; frontal area large, semicircular, indistinct; frontal carinae short; scape extends beyond the occiput by twice thickness; first segment as long as three following, second and third equal, as broad as long, fourth and fifth equal, slightly longer than broad, rest longer than broad. apical as long as two preceding; eyes rather small, convex, placed at centre of sides.

Pronotum more than three times as broad as long, sides and front feebly convex, angles rather abrupt; mesonotum longer than broad, broader in front than behind, sides very feebly convex; meso-epinotal suture very deep and wide; epinotum slightly broader behind than in front, sides and posterior border almost straight, dorsum concave, stigma-bearing spines straight, stout, slightly longer than broad at base, directed backwards and slightly upwards. In profile anterior half of pronotum almost vertical, posterior half feebly convex; mesonotum feebly convex; meso-epinotal suture deep; anterior third of dorsum of epinotum vertical, rest flat and horizontal, and half as long as feebly concave declivity.

Node rather thick, three times as broad as long, anterior border convex, posterior border straight, angles sharp, dorsum concave in middle. In profile thick, as high as epinotum, nearly three times as high as long at base, feebly convex anterior border meeting the straight posterior border at a point; lateral spines small.

Female. Length 3·2 mm. Colour and sculpture of worker.

Head as in worker; eyes placed a little further back; ocelli very indistinct, they appear to be missing in some examples; or represented by merely a deep pit for the anterior ocellus.
Pronotum three as broad as long, sides and anterior border feebly convex, corners rounded; mesonotum short, one and a half times as broad as long, parapsidal furrows short and feebly impressed; scutellum broader than long, broader in front than behind; epinotum broader than long, sides and posterior border almost straight; the wings are short and extend only as far as the first segment of the gaster. Rest as in worker.

Male unknown.

Collected by Dr. W. M. Wheeler.

Material examined. A large number of both workers and females.

Type locality. Margaret River, Western Australia.

STIGMACROS (COMPOSTIGMACROS) EPINOTALIS sp. nov., figs. 89-91.

Worker. Length 2-3 mm. Head and gaster black, epinotum very dark brown, rest of thorax node, legs, antennae and mandibles reddish yellow, funiculus darker.

Smooth and shining.

Head slightly longer than broad, as broad in front as behind, sides almost straight, occipital border feebly convex, angles rounded; mandibles with four teeth; clypeus rounded in front and above not carinated; frontal area semi-circular, posterior border indistinct; frontal carinae moderately long, parallel; scape extends beyond the occiput by a quarter; first segment as long as the two following, second shorter than third, broad as long, rest longer than broad, apical segment as long as two preceding; eyes flat, placed at the middle of the sides.

Pronotum twice as broad as long, sides and front convex, angles rounded; mesonotum longer than broad, broader in front than behind; meso-epinotal suture deep; epinotum broader than long, much broader behind than in front, sides feebly convex, and appear to merge into the spines which are very near the top of the declivity, posterior border concave. In profile pro-mesonotum flat, horizontal, meso-epinotal suture deep; epinotum flat, almost as long as the straight declivity; the spines on declivity very near the top, longer than broad at base, sharp.

Node reduced to a line, anterior border convex, posterior border convex, dorsum concave. In profile as high as the epinotum anterior border convex meeting the concave posterior border at a point, lateral teeth present. Legs slender.

Male and *female* unknown.

Collected by J. Clark, Esq.

Material examined. Twenty-six workers.

Type locality. Booang, Western Australia.

STIGMACROS (CAMPOSTIGMACROS) RETICULATA Clark, figs. 92-94.

Stigmacros reticulata Clark. Proc. Roy. Soc. Vict. 42, pt.2, p.127, 1929 ♀ ♀

Worker. Length 2·2-2·6 mm. Black, mandibles, antennae, except for the apical segments, tibiae and tarsi testaceous. Apical segments of the antennae and the femora brown.

Subopaque. Gaster smooth and shining. Head, thorax and node finely and densely reticulate.

Hair yellow, very short and sparse throughout. Pubescence very fine and adpressed, confined to the antennae and legs.

Head slightly longer than broad, the occipital border straight, the sides convex. Frontal carinae short, flattened parallel. Clypeus convex above, the anterior border convex and feebly emarginate in the middle. Eyes large, rather flat, placed at the posterior third of the sides. Scapes extending beyond the occipital border by barely one-quarter of their length; first segment of funiculus one-third longer than the second; mandibles armed with five sharp irregular teeth. Thorax one and three-quarter time longer than broad. Pronotum twice as broad as long, strongly convex in front and on the sides. Mesonotum longer than broad, broader in front than behind, convex above. Epinotum one-third broader than long, the posterior border concave, the angles bluntly produced; in profile the declivity abrupt, feebly concave, longer than the dorsum, the top angles produced, there is a long, sharp spine on each side at the superior third, longer than broad at the base, directed backward and outward. Node scale-like, four times broader than long, convex in front, straight behind, dorsum bluntly pointed, feebly concave in middle; in profile four times higher than long, the anterior face convex, the posterior feebly concave. Gaster longer than broad, concave in front below. Legs long and slender.

Female. Length 3·3 mm.

Closely resembles the worker, but differs in the following particulars:—The whole of the legs and the coxae testaceous, mandibles, antennae and node darker. Eyes larger, more convex. Ocelli large. Mesonotum large, with a distinct longitudinal carinae in the middle, parapsidal furrows distinct. Scutellum large, broader in front than behind. Epinotum fully twice as broad as long, the spines much stronger. Node more distinctly notched on top. Wings missing.

Male. Unknown.

Collected by J. Clark, Esq.

Type locality. Perth, Western Australia.

Type. Type in the National Museum, Victoria.

STIGMACROS (CAMPOSTIGMACROS) ANTHRACINA sp. nov., figs. 95-97.

Worker. Length 2·3 mm. Black, gaster very dark brown, legs and mandibles and antennae yellowish brown.

Pronotum and mesonotum densely finely longitudinally striate, epinotum more transverse but not so densely striate, head and gaster smooth.

Hair yellowish confined to front of head, pubescence greyish, confined to funiculus.

Head slightly longer than broad, about as broad in front as behind, sides very feebly convex, posterior border almost straight, corners rounded; mandibles with four sharp teeth; clypeus rounded above and in front, not carinated; frontal area semicircular, distinct; frontal carinae short, parallel; scape extends beyond

the occipital border by a quarter; first segment of funiculus as long as the two following, second as long as broad, slightly smaller than third, rest longer than broad; eyes moderately large, convex, placed at middle of sides.

Pronotum three times as broad as long, sides and front almost straight; mesonotum as broad as long, broader in front than behind, sides margined and very feebly convex; epinotum one and a half times as broad as long, broader behind than in front, sides straight posterior corners produced, posterior border almost straight. In profile pronotum and mesonotum straight and horizontal; epinotum straight half as long as the straight declivity; the spines on dorsum long, directed backwards, at upper third of declivity the spines are long and sharp, about twice as long as those at end or dorsum.

Node about four times as broad as long, borders feebly convex, concave dorsum. In profile anterior feebly convex border is rounded into the short dorsum which meets the straight posterior border at a point, lateral spines distinct. Legs robust.

Male and *female* unknown.

Collected by A. M. Lea, Esq.

Type locality. Mt. Lofty, South Australia.

STIGMACROS (CAMPOSTIGMACROS) NITIDA sp. nov., figs. 98-100.

Worker. Length 2 mm. Head very dark reddish brown, thorax very slightly lighter, mandibles, antennae and legs dull brown.

Smooth and shining, sides of epinotum very densely microscopically punctate.

Head one-fifth longer than broad, as broad in front as behind, sides and occipital border almost straight, corners rounded; mandibles with four small sharp teeth; clypeus rounded in front and above, not carinated; frontal area semicircular indistinct; frontal carinae straight and parallel; scape extends beyond the occiput by a sixth; second and third segments of funiculus equal broad as long, rest longer than broad, eyes flat, placed just behind the middle of the sides.

Pronotum twice as broad as long, sides and front convex, corners rounded; mesonotum longer than broad, broader in front than behind, sides almost straight; epinotum a little broader behind than long, broader behind than in front, sides and posterior border almost straight, corners sharp. In profile promesonotum almost straight and horizontal; epinotum very feebly convex, as long as very feebly concave declivity, angle sharp; at upper third spines sharp and slender directed backwards.

Node reduced to a transverse line, concave on top. In profile narrow, anterior feebly convex border meeting the feebly concave border at a point. Legs robust.

Male and *female* unknown.

Collected by F. P. Spry, Esq.

Material examined. Ten workers.

Type locality. Fern Tree Gully, Victoria.

STIGMACROS (CAMPOSTIGMACROS) PILOSELLA Viehmeyer, figs. 101-103.

Acantholepis (*Stigmacros*) *pilosella* Viehmeyer, Ent. Mitt. Berl. 14, p.33, 1925 ☿

Worker. Length 2 mm. Head reddish brown, pronotum and mesonotum, node, legs, antennae more yellowish brown, epinotum, except for the yellowish spines, and also the gaster black or brownish black.

Smooth and shining, sides of meso-epinotum feebly shagreened.

Hair hardly noticeable; pubescence yellowish, adpressed, fine, confined to the funiculus.

Head one-third longer than broad, sides convex, occipital border convex, posterior angles rounded; mandibles triangular with four small sharp teeth; clypeus rounded above, not carinated, anterior border rather straight in middle; frontal area indistinct; frontal carinae short and straight; scapes extend beyond the occiput by about a fifth; first segment of funiculus as long as the two following, second to fifth almost equal, little longer than broad, rest nearly twice as long as broad, apical as long as the preceding two; eyes moderately large, placed just behind the middle of the sides.

Pronotum twice as broad as long, sides and anterior border feebly convex; promesonotal suture deep; mesonotum as broad as long, sides straight and posterior corners produced backwards as very small teeth; no metanotum but a deep wide suture before the epinotum; epinotum twice as broad behind as in front, sides feebly convex and produced behind as small teeth which curve inwards slightly at the tips, posterior border feebly concave though the spines give the appearance of a stronger curve. In profile pronotum is convex in front, the posterior half of pronotum, and the mesonotum almost horizontal and flat; meso-epinotal suture deep; dorsum of epinotum rises abruptly from this suture, convex one-third as long as the declivity; epinotal spines long, slender, directed backwards and slightly upwards.

Node elliptical, five times as broad as long, anterior border feebly convex, posterior border almost straight, upper surface entire. In profile very slender with borders almost straight, bluntly pointed at top, the spines on the sides hardly noticeable. Legs robust.

Male and *Female* unknown.

Collected by J. W. T. Armstrong, Esq.

Redescribed from specimens taken at Nyngan, New South Wales.

Type locality. Liverpool, New South Wales.

Type in Viehmeyers collection, Museum Anthrop. Zool., Dresden.

STIGMACROS (CAMPOSTIGMACROS) ELEGANS McAreavey, figs. 104-106.

Stigmacros elegans McAreavey Proc. Linn. Soc. N.S.W., 74, pts. 1-2, p.24, 1949 ♂ ♀

Worker. Length 1·8-2 mm. Head and thorax shining black; node very dark brown on top but light brown towards the base; gaster clear brown or amber; legs, mandibles and antennae brownish yellow with funiculus slightly darker.

Head shining, shagreened and almost punctate; thorax, node and gaster smooth and shining except for some very scattered elongated scratches.

Pilosity hardly noticeable on any part of body.

Head, excluding mandibles, slightly longer than broad; sides feebly convex, occipital border straight, corners rounded; mandibles triangular with at least four strong teeth; clypeus convex above, anterior border rounded; frontal area indistinct; frontal carinae short, almost parallel; scape extends beyond occiput very slightly, by a thickness; first segment of funiculus as long as two following, second to eighth as broad as long, ninth twice as long as broad; apical nearly three times as long as broad, and longer than two preceding; eyes large, convex, placed at middle of sides.

Pronotum twice as broad as long, strongly convex in all directions; promesonotal suture deeply impressed; mesonotum slightly broader than long, broader in front than behind, sides convex; meso-epinotal suture deep and wide; epinotum nearly twice as broad as long, broader behind than in front, anterior corners rounded, sides almost straight, posterior border concave. In profile the pronotum and mesonotum are flat, rounded in front and truncated behind. The dorsum of epinotum is flat and shorter than the slightly concave declivity, which is almost at right angles to the dorsum. Very near the top of the declivity is a short broad tooth directed backwards.

Node transverse, three times as broad as long, feebly notched on top. In profile it is thorn-like, twice as high as long, the anterior face feebly convex and rounded into the short dorsum, while the posterior face is almost straight and vertical. Legs short and robust.

Female. Length 2-2·8 mm. Colour as in worker, but the gaster is much darker.

Sculpture as in worker but the thorax is more shagreened, especially on the epinotum.

Head as in worker, except there are three very small and indistinct ocelli. Pronotum is almost three times as broad as long, with anterior border and sides almost straight, anterior corners abrupt, almost right-angles, though not sharp; mesonotum broader than long with distinct parapsidal furrows; scutellum large, broader than long, slightly broader in front than behind; rest as in worker.

Male unknown.

Collected by J. W. T. Armstrong, Esq.

Type locality. Nyngan, New South Wales.

Type. Holotype worker in Collection at Commonwealth Scientific and Industrial Research Organization, Canberra.

STIGMACROS (CAMPOSTIGMACROS) AEMULA Forel, figs. 107-112.

Stigmacros aemula Forel, Fauna S-W. Aust. 1, p.298, 1907

Stigmacros aemula Emery, Gen. Insect. fasc. 183, p.34, 1925

Stigmacros aemula Wheeler, Journ. Roy. Soc. W.A. p.159, 1934 ♀

Worker. Length 1·7-2 mm. Colour varies slightly; some examples almost uniformly brown, often head and gaster dark reddish brown or brownish black; thorax and node reddish brown with mesonotum lighter; funiculus brown; legs, scapes and mandibles reddish yellow. In examples with thorax lighter red the epinotum has a black margin on the sides.

Shining head smooth with very faint rugae around the insertions of scapes and on occiput; thorax microscopically rugulose longitudinally, more transversely so on epinotum, anterior face of node microscopically punctate.

Almost hairless, pubescence yellowish, fine adpressed, confined to funiculus and legs.

Head rectangular, one-fifth longer than broad, sides almost straight, occipital border feebly concave, posterior angles rounded, mandibles with five small sharp teeth; clypeus not extending to the corners of head, rounded above, not carinated, anterior border rounded and very slightly impressed at the centre; frontal area semicircular, rather indistinct; frontal carinae short, almost parallel; scapes

extend beyond the occiput by sixth; first segment of funiculus almost as long as three following, second to seventh broad as long, rest longer than broad, apical as long as the two preceding; eyes placed at middle of sides.

Pronotum twice as broad as long, front convex, sides almost straight, broader in front than behind; mesonotum as long as broad narrowed behind, sides very feebly convex; epinotum nearly twice as broad behind as long, anterior border three-quarters the length of posterior border, anterior border and sides straight, posterior border concave; epinotal spines long, sharp and slender, directed backwards, and slightly outwards. In profile whole dorsum is flat with anterior border rounded and epinotal declivity which is slightly longer than dorsum of epinotum, almost straight and vertical; epinotal spines at upper third.

Node very short, anterior border convex, posterior border concave, dorsum slightly concave. In profile narrow, though the curved anterior face gives the appearance of a broad node, anterior border convex meeting the almost straight posterior border at a point; lateral teeth small. Legs robust.

Female. Length 2·5 mm. Dark brown, legs, node, scape, mandibles more yellowish brown.

Sculpture of worker but head and thorax has also microscopic punctation.

Head similar to that of worker but sides more convex, occipital border almost straight; mandibles with stout teeth the apical one being very long; frontal groove reaches anterior ocellus; eyes large placed slightly behind middle of sides; ocelli small but distinct.

Pronotum from above sort, anterior border convex, sides almost straight, corners rounded; mesonotum broader than long, parapsidal furrows impressed, scutellum large, broader than long, broader in front than behind; epinotum three times as broad as long, broader behind than in front, sides almost straight, anterior and posterior borders concave. In profile pronotum convex feebly, mesonotum higher than pronotum and scutellum, feebly convex; scutellum straight, epinotum feebly convex and half as long as the almost straight declivity.

Node larger than that of worker, anterior border convex, posterior border straight. In profile similar to that of worker. Gaster moderately large. Legs relatively more slender, but nevertheless robust.

Male.—Unknown. Redescribed from large numbers of specimens taken by Miss A. Baesjou, of Booanya, Western Australia.

Type locality. Fremantle, Western Australia.

Type. In Forel's collection, Museum of Natural History, Geneva.

STIGMACROS (CAMPOSTIGMACROS) INTACTA Viehmeyer, figs. 112-114.

Stigmacros aemula var. intacta. Viehmeyer, Ent. Mitt. Berl. 14, p.34, 1925 ☿

Worker. Length 2-2·2 mm. Head and gaster brownish black; pronotum and mesonotum reddish brown; epinotum and node darker brown; legs, scape and mandibles reddish yellow.

Smooth and shining; epinotum feebly shagreened.

Head slightly longer than broad, as broad in front as behind, sides very feebly convex, occipital border straight, posterior angles rounded; mandibles with four small teeth; clypeus not carinated, extending to corners of head, anterior border entire and rounded; frontal area semi-circular, rather indistinct; frontal carinae short, almost parallel; scape extends beyond occiput by fifth; first

segment as long as two following, second slightly longer than third, fourth to seventh as broad as long, rest longer than broad; eyes moderately large, flat, placed at middle of sides.

Pronotum one and three-quarter times as broad as long, front convex, sides almost straight; mesonotum as long as broad in front, narrowed behind, sides almost straight; epinotum broader than long, broader behind than in front, sides straight, posterior border feebly concave, dorsum slightly concave. In profile pro-mesonotum forms a very feeble convexity, almost flat; dorsum of epinotum feebly convex and as long as the almost straight declivity; epinotal spines long, sharp and slender.

Node very short with convex anterior border and concave posterior border, dorsum concave. In profile narrow, feebly convex, anterior border meeting almost straight posterior border at a sharp point. On each side about the middle is a small triangular tooth directed outwards. Legs robust.

Male and *Female* unknown.

Redescribed from specimens taken by E. Sutton, at Stanthorpe, Queensland.

Type Locality. Trial Bay, New South Wales.

Type. In Viehmeyer's collection, Museum Anthrop. Zool., Dresden.

STIGMACROS (CAMPOSTIGMACROS) STANLEYI sp. nov., figs. 115-117.

Worker. Length 2 mm. Head, thorax and node reddish brown, mandibles, antennae and legs yellowish brown, gaster dark brown.

Head smooth with sparse microscopic punctures; thorax microscopically densely reticulate punctate; node and gaster smooth.

Hair very sparse, silvery, confined to clypeus and apex of gaster; pubescence silvery, adpressed, confined to funiculus.

Head one-fifth longer than broad, sides and occipital border feebly convex, angles rounded; mandibles with five sharp irregular teeth; clypeus not carinated, rounded above and in front; frontal area semicircular, indistinct; frontal carinae very short, almost parallel; scape extends beyond the occipital border by almost a sixth; first segment longer than the two following, second to fourth almost equal, as broad as long, rest longer than broad, apical as long as two preceding; eyes flat, placed about the middle of sides.

Pronotum twice as broad as long, front and sides feebly convex, corners rounded; mesonotum longer than broad in front, broader in front than behind, sides very feebly convex; epinotum broader than long, broader behind than in front with sides and posterior border almost straight, posterior corners sharp; spines on declivity long, robust, directed backwards and slightly outwards. In profile thorax flat, almost straight with a deep impression at the meso-epinotal suture; dorsum of epinotum flat and shorter than the almost straight declivity.

Node almost reduced to a margined line, anterior border convex, posterior border concave, dorsum slightly concave. In profile scale-like, anterior convex border meeting the straight posterior border at point; lateral teeth small. Legs short, robust.

Male and *Female* unknown.

Collected by J. McAreavey.

Material examined. Seventeen workers.

Type locality. Greensborough, Victoria.

STIGMACROS (CYRTOSTIGMACROS) Subgenus novum.

Pronotum and mesonotum convex with the suture between very faint. The metanotum is distinct and in profile it appears as small cone or hump. On each side is a distinct spiracular tubercle. Between the metanotum and epinotum is a merked depression. The epinotum is armed with small spines placed about the middle on each side of the declivity. In many species the node is armed with tiny lateral teeth.

Subgenotype *Acantholepis* (*Stigmacros*) *australis* Forel.

Key to species.

1. Dorsum of epinotum broader than long. 8
—. Dorsum of epinotum not distinctly broader than long. 2

2. Scape extends beyond occiput by more than third of its length. .. 3
—. Scape not extending beyond occiput by more than third. .. 4

3. Head and dorsum of thorax entirely smooth. Black or deep reddish brown. Length 3·3 mm. .. .. *australis* Forel.
—. Head and dorsum of thorax not entirely smooth. Castaneous with back of head darker. Length 2·7-3·4 mm. .. *termitoxenus* Wheeler.

4. Clypeus carinated 5
—. Clypeus not carinated. Dark brown with antennae, legs and mandibles yellowish brown. Length 2·3-2·5 mm. .. *striata* sp. nov.

5. Clypeus produced to a point in front. Black, antennae, mandibles, legs reddish brown. Length 3·8 mm. .. .. *major* sp. nov.
—. Clypeus not produced to a point in front. 6

6. Dorsum of epinotum more than a third of declivity. 7
—. Dorsum of epinotum not more than third of declivity. Reddish brown, legs, antennae and mandibles lighter. Length 2·1-2·3 mm. .. .. .. *ferruginea* sp. nov.

7. Scape extends beyond occiput by third. Brownish black, legs, and antennae lighter. Length 2-2·5 mm. .. .. *lanaris* sp. nov.
—. Scape extends beyond occiput by quarter. Yellowish brown, head and posterior two-thirds of gaster darker, legs, mandibles, antennae paler brown. Length 1·9-2·5 mm. .. .. *occidentalis* Clark.

8. Clypeus carinated 9
—. Clypeus not carinated 14

9. Dorsum of epinotum at least one and a half times as broad as long 10
—. Dorsum less than one and a half times as broad as long. .. 11

10. Scape extends beyond occiput by a third. Deep reddish brown, mandibles, antennae, legs lighter. Length 2·7-3·2 mm. .. .. *clivispina* Forel.
—. Scape extends beyond occiput by quarter. Dull yellow, posterior half of gaster darker. Length 2·2 mm. .. .. *flava* sp. nov.

11. Scape extends beyond occiput by third. 12
—. Scape extends beyond occiput by less than third. 13

12. Colour uniform; reddish brown. Length 2·3-2·6 mm. .. .. *castanea* sp. nov.
—. Colour not uniform; head and gaster almost black, rest brownish. Length 2-2·2 mm. .. .. *extreminigra* sp. nov.

13. Thorax densely reticulate. Rich reddish brown, legs and antennae yellowish. Length 2·5 mm. . . . . *aciculata* sp. nov.
—. Thorax not densely reticulate. Dull yellow, head and gaster slightly darker. Length 2 mm. . . . . *clarki*, sp. nov.

14. Scape extends beyond occiput by less than third. 15
—. Scape extends beyond occiput by a third. Dull yellowish brown antennae, thorax, legs slightly lighter. Length 2 mm. . . *sordida* sp. nov.

15. Thorax densely reticulate. Head and gaster dark reddish brown, thorax, node, legs, antennae dark brown. Length 2mm. . . . . *glauerti*, sp. nov.
—. Thorax not densely reticulate 16

16. Dorsum of epinotum less than one and a quarter times as broad as long. Yellowish brown, antennae, legs, lighter. Length 2·2-2·9 mm. . . . . *proxima* sp. nov.
Dorsum of epinotum one and a quarter times as broad as long. . . 17

17. Segments of funiculus twice as long as broad. Head and gaster dull yellowish brown, rest lighter. Length 2·5 mm. . . . . *brooksi* sp. nov.
Segments of funiculus not twice as long as broad. Dull brownish yellow. Head and gaster darker, antennae and legs yellow. Length 2·5-2·8 mm. . . . . *armstrongi* sp. nov.

STIGMACROS (CYRTOSTIGMACROS) AUSTRALIS Forel, figs. 118-121.

Acantholepis (*Acrostigma*) *australis* Forel, Rev. Suisse Zool., 10, p.479, 1902

Acantholepis (*Stigmacros*) *australis* Forel, Ann. Soc. Ent. Belg., 49, p.179 1905

Stigmacros Emery, Genera Insect. fasc., 183, p.34, 1925 ♀

Worker. Length 3·3-3·6 mm. Varying in colour from reddish brown with mandibles, antennae and legs lighter to black with thorax brownish black, and mandibles, legs, antennae brownish red.

Smooth and shining except base of sides of mesonotum and epinotum which are feebly shagreened.

Hair yellowish, erect, very sparse, confined to mandibles, clypeus and apex of gaster; pubescence yellowish, fine adpressed, confined to the funiculus.

Head as broad as long, broader behind than in front, with sides and occipital border convex, posterior corners broadly rounded; mandibles triangular with four or five small sharp teeth; clypeus feebly carinated on anterior half, and terminated in front by a very small tooth, anterior border rounded; frontal area semicircular, distinct; frontal carinae short, diverging slightly behind; scape extends beyond the occipital border by half its length, first segment of funiculus as long as the two following, second and third almost equal, longer than broad, rest nearly twice as long as broad, apical as long as the preceding two; eyes moderately large, placed at the posterior third of sides of head.

Thorax twice as long as broad, and more than twice as broad across the pronotum as across the epinotum; pronotum slightly more than twice as broad as long, anterior border almost straight, anterior angles rounded, sides feebly convex, dorsum feebly impressed longitudinally in middle; mesonotum as broad as long, broader in front than behind, with sides almost straight, meta-epinotal suture indicated by a distinct transverse impression; metanotum distinct, elevated with two moderately prominent stigmata; meta-epinotal suture deep and wide; epinotum almost square, very slightly broader than long sides straight and

margined, posterior border feebly concave, the dorsum feebly concave and distinctly angulate behind. In profile pronotum convex; mesonotum evenly convex and slightly higher than the pronotum; metanotum raised as a small very distinct hump; anterior border of epinotum sloping, rest of dorsum flat and horizontal and half as long as the very feebly concave sloping declivity; sharp small stigma-bearing spines at the upper third of the declivity, directed backwards and upwards.

Node transverse with anterior border convex, posterior border straight, corners sharp, dorsum concave in middle. In profile node thin, as high as epinotum with feebly convex anterior face meeting straight posterior border at a sharp point; about middle of each side is a small tooth directed outwards. Legs rather long and slender.

Male and *Female* unknown.

Material examined. Fourteen workers collected by Dr. W. M. Wheeler, at Heathcote, New South Wales.

Type locality. Richmond, New South Wales.

Type. In Forel's collection, Museum Natural History, Geneva.

STIGMACROS (CRYTOSTIGMACROS) TERMITOXENUS Wheeler, figs. 122-124.

Stigmacros termitoxenus Wheeler, Proc. Amer. Acad. Arts and Science, 71, No.3, p.215, 1936 ☿ ♀

Worker. Length 2·7-3·4 mm. Castaneous, posterior portion of head darker, sometimes gaster also darker; mandibles, antennae, legs and petiole pale yellowish brown.

Recticulate especially on back of head and the thorax; mandibles smooth and shining with a few small punctures.

Hair whitish, sparse, confined to front of head and gaster; pubescence white, adpressed, confined to antennae and legs.

Head slightly longer than broad, broader behind than in front, sides feebly convex, occipital border straight, posterior corners rounded; mandibles narrow with four teeth of which apical is longest; clypeus convex, sharply carinated, anterior border broadly rounded; frontal area semicircular, posterior margin faint; frontal carinae straight, diverging slightly behind; scapes extend beyond the occipital border by slightly more than two-fifths of their length; first segment of funiculus as long as two following, second segment one and a half time as long as broad, rest twice as long as broad, apical almost as long as two preceding together; eyes rather large, and convex, placed just behind the middle of the sides.

Pronotum twice as broad as long, sides and anterior border feebly convex, anterior angles rounded, dorsum impressed slightly in middle; pro-esonotal suture impressed; mesonotum one-quarter longer than broad, broader in front than behind, sides straight; meso-metanotal suture merely indicated by transverse impression; metanotum distinct, twice as broad as long, with raised stigmata; meta-epinotal suture deep; epinotum longer than broad with sides and posterior border almost straight, posterior angles sharp. In profile anterior half of pronotum sloping, posterior half rather flat; mesonotum feebly convex; metanotum raised at a small hump; dorsum of epinotum feebly convex, and half as long as the feebly concave posterior border; stigma-bearing spines on each side of the declivity small, sharp, not longer than wide at base.

Node transverse, very feebly concave in centre. In profile thin, as high as epinotum with distinctly convex anterior border meeting the straight posterior border at a point; on each side is a small tooth, directed outwards and upwards. Legs rather long.

Redescribed from co-type workers.

Female. As described by Dr. W. M. Wheeler (page 217). (Apterous and ergatomormorphic). Length 4·6 mm. Closely resembling the worker, but the head is broader, as broad as long, with somewhat less convex sides, slightly larger eyes but without ocelli. Thorax stouter, its pronotum broader in proportion to its length and with more prominent humeri; mesonotum as broad as long and more convex than in worker. Petiole slightly higher than epinotum and even thinner than in worker, with the apical border narrower and distinctly emarginate in the middle. Gaster very large, physogastric, decidedly longer than the head and thorax together.

Sculpture, pilosity and colour as in the worker except that the legs are paler yellow and the gaster is brown like the thorax.

Male. Unknown.

Material examined. Originally described by Professor Wheeler from ten workers and a single female, taken from a small termitary of *Nasutitermes* (*Tumulitermes*) *peracutus* Hill.

Type locality. Mullewa, Western Australia.

Type. In Collection at Harvard University, Washington, U.S.A.

STIGMACROS (CRYTOSTIGMACROS) STRIATA sp. nov., figs. 125-127.

Worker. Length 2·3-2·5 mm. Dark brown, antennae, legs, mandibles yellowish brown.

Head smooth, pronotum transversely striate, mesonotum longitudinally striate, epinotum transversely striate.

Head slightly longer than broad, sides feebly convex, occipital border almost straight, posterior corners rounded; mandibles triangular, with four reddish sharp teeth; clypeus rounded above, not carinated, anterior border rounded; frontal area semicircular, distinct; frontal carinae short and straight; scape extends beyond the occipital border by a third, first segment of funiculus as long as the two following, third longer than broad, rest twice as long as broad, apical as long as two preceding; eyes rather flat, placed just behind the middle of sides.

Pronotum twice as broad as long, sides and anterior border feebly convex, anterior corners abrupt; mesonotum about as broad as long, with sides almost straight; metanotum raised with two stigmata, epinotum slightly broader than long, slightly broader in front than behind, sides and posterior border almost straight, posterior corners rounded, dorsum concave. In profile pronotum and mesonotum form an even low convexity; metanotum raised as a hump; epinotum straight about half as long as the straight declivity; at upper third the stigma-bearing spines are long, sharp and slender, directed backwards and upwards.

Node almost reduced to a transverse line, anterior border feebly convex, posterior border straight, dorsum concave in centre. In profile node thin, the feebly convex anterior border meets the feebly concave border at a point. On each side is a small spine. Legs robust.

Female. Length 3·1 mm.

Colour and pilosity of worker.

Head similar to that of worker but slightly broader; eyes very large and very convex; ocelli small but distinct; scapes extend beyond the occipital border by a fifth.

Thorax smooth except for traces of reticulation on epinotum. Pronotum hardly noticeable from above; mesonotum broad as long with parapsidal furrows impressed; scutellum broader than long, triangular, broader in front than behind; mesoepinotal suture wide; epinotum three times as broad as long, broader in front than behind, sides and posterior border almost straight, posterior corners rounded. In profile pronotum vertical; mesonotum with anterior third convex, rest of mesonotum and scutellum straight and horizontal; epinotum straight and rounded into the declivity which is twice as long as the dorsum; on each side about the middle is a small tooth.

Node about five times as broad as long, not concave in middle. In profile node as high as the epinotum, three times as high as long, anterior and posterior borders almost straight, upper border convex. Legs slender.

Male. Length 2·5 mm. Uniformly brown with mandibles yellowish.

Smooth except for traces of reticulation on sides of epinotum.

Head as broad as long, sides convex, occipital border feebly convex, posterior corners rounded; mandibles small, denticulate; clypeus rounded above and in front, not carinated; frontal area triangular, distinct; frontal carinae short, diverging slightly behind; scapes extend beyond occipital border by almost a third, all segments longer than broad; eyes large, hemispherical; ocelli whitish, distinct.

Pronotum narrow, hardly noticeable from above; mesonotum slightly broader than long, parapsidal furrows distinct; scutellum broader in front than behind, broader than long; epinotum almost three times as broad as long, merging into the declivity so that the posterior border is difficult to see, the stigma-bearing spines are very small. In profile pronotum vertical; mesonotum scutellum and postscutellum feebly convex; epinotum short, convex, rounded into the feebly convex declivity.

Node four times as broad as long, anterior border feebly convex, posterior border feebly concave, sides convex. In profile node as high as the epinotum, about two and a half times as high as long, with anterior and posterior borders feebly convex. Legs slender.

Collected by Dr. W. M. Wheeler.

Material examined. Thirty workers, four females and five males.

Type locality. Hornsby, New South Wales.

STIGMACROS (CYRTOSTIGMACROS) MAJOR sp. nov., figs, 128-130.

Worker. Length 3·8 mm. Shining black, antennae reddish brown, mandibles and legs reddish brown.

Smooth and shining.

Hair brown confined to clypeus and apex of gaster; pubescence greyish, adpressed confined to funiculus.

Head slightly longer than broad, broader behind than in front, sides feebly convex, occipital border almost straight, posterior corners rounded; mandibles triangular with four moderately large, sharp teeth; clypeus strongly carinated, produced to a point in front; frontal area semicircular, distinct; frontal carinae as long as distance apart, diverging slightly behind; scape extends beyond occipital border by a third; first segment of funiculus as long as the two following, second slightly shorter than third; rest longer than broad, apical as long as the two preceding; eyes rather small, rather flat, placed just behind the middle of the sides.

Pronotum nearly three times as broad as long, sides and anterior borders feebly convex, dorsum depressed in middle; meso-metanotal suture impressed; mesonotum as broad as long, broader in front than behind, sides almost straight; metanotum raised, stigmata distinct; meta-epinotal suture deep and broad; epinotum very slightly broader than long, very slightly broader in front than behind, sides and posterior border almost straight, posterior corners sharp, dorsum concave. In profile pronotum with anterior half convex, posterior half rather flat; mesonotum feebly convex; metanotum raised as a small hump; epinotum almost straight, about one-quarter shorter than the feebly concave declivity, posterior corners produced as sharp short teeth; at upper third on each side a sharp, slender spine, directed backwards and upwards.

Node large, elliptical, three times broader than long with anterior and posterior borders convex, dorsum concave in middle. In profile node three times as high as long, anterior border convex meeting the almost straight posterior border at a point. There are no spines on the sides of node. Legs robust.

Male and *Female* unknown.

Collected by H. Hacker, Esq.

Type locality. National Park, Queensland.

STIGMACROS (CRYTOSTIGMACROS) FLAVA sp. nov., figs. 131-133.

Worker. Length 2·2 mm. Very dull yellow with posterior half of gaster darker.

Head very finely shagreened, thorax shagreened, sides of thorax densely microscopically reticulate; gaster smooth.

Head slightly longer than broad, broader behind than in front, sides convex, occipital border straight, posterior angles rounded; mandibles with four sharp, dark teeth; clypeus carinated rounded in front; frontal area small semicircular; frontal carinae straight and as long as distance apart; scapes extend beyond the occipital border by a quarter; first segment as long as the two following, second shorter than the third, third to fifth equal, a little longer than broad, rest twice as long as broad, apical as long as the two preceding; eyes moderately large, convex, placed just behind the middle of the sides.

Pronotum three times as broad as long, sides and anterior border feebly convex, anterior angles rounded; mesonotum broad as long, broader in front than behind, sides almost straight; meso-metanotal suture faint; metanotum raised with distinct stigmata; meta-epinotal suture broad; epinotum almost twice as broad as long, slightly broader in front than behind; sides feebly convex, posterior border straight, posterior angles sharp dorsum concave. In profile anterior half of pronotum vertical, posterior half flat; mesonotum convex; metanotum hump-shaped; epinotum straight, long as the feebly concave declivity, posterior corners sharp; at upper third the spines on the declivity are stout and sharp, directed backwards and upwards.

Node reduced to a transverse line, anterior border feebly convex, posterior border straight. In profile thin, anterior border feebly convex meeting the straight posterior border at a point. No spines on the sides. Legs slender.

Male and *Female* unknown.

Collected by J. Clark, Esq.

Material examined. Twenty-eight workers.

Type locality. Mundaring, Western Australia.

STIGMACROS (CYRTOSTIGMACROS) GLAUERTI sp. nov., figs. 134-136.

Worker. Length 2 mm. Head and gaster dark reddish brown, thorax, node, legs, antennae dark brown.

Head smooth and shining; thorax densely, very finely microscopically punctate, sides more transversely striate.

Head longer than broad, as broad in front as behind, sides feebly convex, posterior border straight, posterior corners rounded; mandibles with four teeth; clypeus not carinated, rounded in front; frontal area small but distinct; semicircular; frontal carinae short and straight; scapes extend beyond the occipital border by a quarter; first segment of funiculus as long as the two following, second a little shorter than the third, both as broad as long, remaining segments longer than broad, apical segment as long as two preceding; eyes moderately large, convex, placed at centre.

Pronotum three times as broad as long, sides and anterior border feebly convex; mesonotum as broad as long, broader in front than behind, sides very feebly convex; meso-metanotal suture indistinct; metanotum raised with distinct stigmata; meta-epinotal suture broad; epinotum one and a quarter times as broad as long, as broad in front as behind, sides straight, posterior border very feebly concave. In profile pronotum convex, mesonotum convex; metanotum hump-shaped; epinotum straight, elevated behind, almost half as long as straight declivity, posterior corners sharp; spines on declivity sharp and slender.

Node reduced to a transverse, concave in centre. In profile slender, anterior feebly convex meeting straight posterior border at point. Legs robust.

Male and *Female* unknown.

Collected by L. Glauert, Esq.

Type locality. Darlington, Western Australia.

STIGMACROS (CYRTOSTIGMACROS) CLARKI sp. nov., figs. 137-139.

Worker. Length 2 mm. Dull yellow with head and gaster slightly darker, mandibles yellow.

Head smooth, thorax faintly shagreened, epinotum more reticulate punctate, declivity rather transversely striate.

Head slightly longer than broad, broader behind than in front, sides feebly convex, posterior border almost straight; mandibles with four sharp teeth; clypeus carinated rounded in front; frontal area distinct; frontal carinae almost straight, as long as distance apart; scape extends beyond the occipital border by a quarter; second segment shorter than third, third to fifth equal slightly longer than broad, rest increasing in length; eyes moderately large, convex, placed just behind middle.

Pronotum about four times as broad as long, sides and anterior border almost straight, angles abrupt; mesonotum as broad as long, sides feebly convex; metanotum raised stigmata distinct; epinotum margined, one and a quarter times as broad as long, slightly broader in front than behind, with sides straight, posterior border very feebly concave, corners sharp, dorsum concave. In profile pronotum convex; mesonotum convex, rather flat, metanotum humped; epinotum straight and half as long as the feebly concave declivity, posterior corner sharp almost toothed; spines on declivity small and blunt.

Node reduced to a transverse line, very slightly concave in middle. In profile thin, anterior feebly convex border meeting almost straight posterior border at a point. Legs slender.

Male and *Female* unknown.

Collected by J. Clark, Esq.

Material examined. Twenty-one workers.

Type locality. Ludlow, Western Australia.

STIGMACROS (CYRTOSTIGMACROS) BROOKSI sp. nov., figs. 140-144.

Worker. Length 2·5 mm. Head yellowish brown with the mandibles lighter yellow; thorax, node and legs yellow; gaster dull brownish yellow.

Head smooth and shining, thorax shagreened, sides of mesonotum and epinotum densely miscroscopically punctate; gaster smooth.

Head one-fifth longer than broad, broader behind than in front, sides feebly convex, occipital border almost straight; mandibles with four small sharp teeth; clypeus not carinated, rounded in front; frontal area semicircular, not very distinct; frontal carinae short, diverging very slightly; scape extends beyond the occipital border by a quarter; second slightly shorter than third, third to ninth about twice as long as broad; eyes large, convex, placed just behind the middle of the sides.

Pronotum about four times as broad as long, sides and anterior border very feebly convex, corners abruptly rounded; mesonotum slightly longer than broad, broader in front than behind, sides very feebly convex; metanotum raised, stigmata distinct; epinotum one and a quarter times as broad as long, slightly broader in front than behind, sides feebly convex, posterior border almost straight, posterior corners rounded, dorsum concave. In profile pronotum convex; mesonotum convex; metanotum humped; epinotum convex in front, the posterior two-thirds straight, elevated behind, about a third as long as the feebly concave declivity, posterior angle sharp; spines on declivity rather slender.

Node reduced to a transverse line, concave in middle. In profile slender, anterior convex border meeting the slightly concave posterior border at a point. Legs slender.

Female. Length 3·1 mm. Head, thorax, node, antennae and legs brownish yellow; gaster very dark brown.

Head similar to that of worker but as broad as long; clypeus very faintly carinate on anterior half; frontal carinae more diverging; eyes large; ocelli white very distinct; scape extends beyond the occipital border by a sixth.

Pronotum short, almost concealed by mesonotum, sides straight, anterior border feebly convex, angles rather abrupt; mesonotum, broader than long, parapsidal furrows very distinct; scutellum triangular, broader in front than

behind, almost triangular; epinotum short about four times as broad as long, merging into the declivity so that the posterior border is indistinct; spines on declivity short and blunt. In profile pronotum vertical; rest of thorax forms a low even convexity; dorsum of epinotum about a third as long as the sloping declivity; the spines on the declivity are hardly noticeable.

Node three and a half times as broad as long, elliptical, dorsum slightly concave. In profile low, twice as high as long, rather thick, anterior and posterior borders almost straight, dorsum rounded. Legs slender.

Male. Length 2·1 mm. Entirely yellowish brown.

Head and thorax smooth with a few scattered striae on thorax.

Head slightly broader than long, sides strongly convex, posterior border feebly convex; mandibles narrow, denticulate; clypeus large, rounded in front not carinate; frontal area triangular, very distinct; frontal carinae diverging behind, short; scapes extend beyond occiput by about half their length; second to fourth segments of funiculus as broad as long, equal, rest longer than broad, apical as long as two preceding; eyes large, hemispherical; ocelli white, very distinct.

Pronotum hardly seen from above; mesonotum large, broader than long, parapsidal furrows very distinct; scutellum triangular, broader in front than behind, broader than long; epinotum short merging into the declivity so it is difficult to judge its size. In profile pronotum vertical; mesonotum convex in front, flattened behind; scutellum feebly convex, dorsum and declivity of epinotum form an even convexity.

Node about three times as broad as long, elliptical, dorsum concave slightly. In profile low, two and a half times as high as long, anterior and posterior borders almost straight dorsum rounded. Legs slender.

Collected by W. S. Brooks, Esq.

Material examined. Twelve workers, three males and two females.

Type locality. Manjimup, Western Australia.

STIGMACROS (CYRTOSTIGMACROS) LANARIS sp. nov., figs., 145-148

Worker. Length 2-2·5 mm. Black or brownish black with antennae, neck, knees, tibiae, tarsi and mandibles reddish brown.

Head smooth and shining, thorax and node feebly shagreened, more so on epinotum, sides of mesonotum and epinotum reticulate punctate, gaster smooth.

Hair yellowish, long, confined to clypeus and apex of gaster, there are also whitish short hairs throughout; pubescence yellowish, confined to funiculus.

Head slightly longer than broad, sides convex, occipital border straight, posterior corners rounded; mandibles triangular, with five small teeth; clypeus rounded above, very feebly carinated on anterior half, anterior border rounded; frontal area semicircular, large frontal carinae straight and almost parallel; scape extends beyond the occipital border by a third; first segment of funiculus as long as two following, second to fifth of equal length, all segments about one and a half times as long as broad, apical as long as the two preceding; eyes rather small, rather flat, placed behind the middle of sides.

Pronotum twice as broad as long, sides and anterior border convex, anterior corners rounded; mesonotum as broad as long, and slightly broader in front than behind; meso-metanotal suture indistinct; metanotum raised, stigmata distinct;

meta-epinotal suture very deep and wide; epinotum slightly broader than long, sides straight, posterior border very feebly concave, dorsum concave. In profile pronotum feebly concave on anterior half, posterior half and mesonotum rather flat; metanotum elevated as a small hump; meta-epinotal suture deep; anterior third of epinotum straight and almost vertical, rest of dorsum straight and horizontal, less than half as long as straight declivity; at upper third are slender stigma-bearing spines, directed backwards and upwards.

Node reduced to a transverse line, the dorsum concave in middle. In profile very slender, as high as epinotal spines, anterior feebly convex border meets straight posterior border in a sharp point. On each side near the base is a small tooth directed outwards. Legs slender.

Female. Length 4·5 mm. Colour, sculpture and pilosity of worker.

Head similar to that of worker, but mandibles with five rather even small teeth; clypeus distinctly carinated; eyes comparatively larger and more convex; scape extends beyond occipital border by a quarter; ocelli present but being dark are not very distinct.

Pronotum from above almost concealed by mesonotum; mesonotum massive, as broad as long, parapsidal furrows marked; scutellum broader than long, broader in front than behind; before the epinotum is a broad suture; epinotum three times as broad as long, broader in front than behind, anterior and posterior borders feebly concave, posterior corners rounded, dorsum slightly concave. In profile pronotum vertical, anterior quarter of mesonotum convex rest of thorax almost horizontal; dorsum of epinotum straight and about a third as long as the sloping declivity; at upper third on each side is a short stout spine, directed backwards and upwards.

Node reduced to a transverse line, feebly concave in middle. In profile node scale-like, anterior border feebly convex, posterior border straight. There are no teeth on the sides of node. Legs short and slender.

Male unknown.

Collected by J. J. McAreavey, for Dr. Claire Burke.

Material examined. Sixteen workers and one female.

Type locality. Pymble, New South Wales.

STIGMACROS (CYRTOSTIGMACROS) OCCIDENTALIS Crawley, figs. 149-151.

Stigmacros occidentalis Crawley, Ann. Mag. Nat. Hist., 9, 10, p.30, 1922

Worker. Length 1·9-2·5 mm. Yellowish brown, sometimes entirely brown, head and posterior two-thirds of gaster darker, mandibles, antennae and legs paler brown.

Head smooth and shining, thorax rugulose longitudinally, epinotum rather transversely so, and declivity of epinotum shining, gaster smooth and shining.

Hair yellowish, confined to the mandibles and apical segment of gaster; pubescence very fine, adpressed, dense on funiculus but elsewhere very short and scattered.

Head as broad as long, slightly broader behind than in front, sides feebly convex, occipital border almost straight, posterior corners rounded; mandibles triangular with five small sharp teeth, apical teeth longer; clypeus convex, sharply

carinated with entire broadly rounded and projecting anterior border, which is very slightly flattened at centre; frontal area large, semicircular with posterior border indistinct; frontal carinae short and diverging slightly; scapes extend beyond the occipital border by almost a quarter of their length; first segment as long as two following, second about as broad as long, third to ninth twice as long as broad, apical as long as two preceding. Eyes slightly convex, placed just behind the middle of the sides of head.

Thorax twice as long as broad, more than twice as broad across the pronotum as across the epinotum; pronotum twice as broad as long with prominent humeri, anterior border and sides almost straight; pro-mesonotal suture distinct; mesonotum longer than broad, broader in front than behind with sides almost straight; meso-metanotal suture obsolete, replaced by a transverse impression; metanotum twice as broad as long with raised stigmata; meta-epinotal suture deep; epinotum almost square with straight, margined sides and straight posterior border, posterior corners sharp, dorsum concave in middle. In profile pronotum has anterior half sloping, and the posterior half horizontal; mesonotum evenly convex and slightly higher than the pronotum; metanotum sharply convex; epinotum almost straight and half as long as the evenly and feebly concave declivity; the stigma-bearing tooth one each side, placed about the centre of the declivity, is small and sharp, not longer than broad at base, directed backwards and slightly upwards.

Node reduced to a transverse line which is deeply concave in middle. In profile thin, as high as the epinotum, with convex anterior border meeting the posterior border at a point. On each side just below the middle is a small broad tooth, directed outwards. Legs robust.

Female. Length 3·5 mm. Head and thorax dark reddish brown, antennae, mandibles, node and pronotum lighter yellowish brown, gaster dark brown.

Smooth with epinotum microscopically densely reticulate punctate.

Head as in worker but the scapes extend beyond the occipital border by a fifth; eyes comparatively larger, ocelli white, clear and distinct.

Pronotum from above short, concealed by the mesonotum, anterior border convex, sides straight, anterior corners abrupt and hardly rounded; mesonotum large, broader than long, the parapsidal furrows distinct; scutellum large, broader than long, broader in front than behind; epinotum short, broader in front than behind, sides feebly convex, posterior border concave, the dorsum concave. In profile pronotum vertical; mesonotum convex and rest of thorax rather flat or feebly convex; epinotum straight and a third of the feebly concave declivity; at the upper third of declivity are small slender spines directed upwards and backwards.

Node reduced to a transverse line, concave in middle. In profile scale like, as high as the dorsum of epinotum with anterior border feebly convex meeting the almost straight posterior face at a point. Gaster large. Legs slender.

Male. Too damaged for description.

Collected by J. Clark, Esq.

Material examined. Thirty workers, one female, and a number of damaged males, taken at Hovea, Western Australia.

Type locality. Murray River, Western Australia.

Type. In Mr. Crawley's collection, British Museum.

STIGMACROS (CYRTOSTIGMACROS) FERRUGINEA sp. nov., figs. 152-154.

Worker. Length 2·1-2·3 mm. Reddish brown, legs yellowish brown, joints of legs, antennae and mandibles yellowish.

Head smooth but the back of the head faintly reticulate; thorax very finely shagreened, sides of mesonotum and epinotum reticulate.

Hair yellowish, confined to the clypeus and apex of gaster.

Head slightly longer than broad, sides feebly convex, occipital border almost straight, posterior corners rounded; mandibles with four small sharp teeth; clypeus rounded in front, carinated; frontal area semicircular, indistinct; frontal carinae short, diverging very slightly; scapes extend beyond the occipital border by a quarter; first segment of funiculus as long as the two following; second to fifth equal, very slightly longer than broad, sixth to ninth longer than broad, apical as long as two preceding; eyes moderately convex, placed just behind the middle of the sides.

Pronotum three times as broad as long, sides and anterior border almost straight, anterior angles abrupt; mesonotum as broad as long, meso-metanotal suture very indistinct; metanotum raised with two distinct stigmata; meta-epinotal suture broad; epinotum slightly broader than long, about as broad behind as in front, sides convex, posterior border feebly concave, posterior angles sharp. In profile pronotum vertical in front, posterior two-thirds rather flat; mesonotum very feebly convex; metanotum hump-shaped; epinotum straight, one-third of the almost straight declivity, posterior angle sharp; at upper third on each side is a sharp spine as long as broad at base, directed backwards.

Node reduced to a transverse line with dorsum concave. In profile slender, anterior feebly convex border meeting the feebly concave posterior border at a point, spines on side not noticeable. Legs slender.

Male and *female* not known.

Collected by A. Elston, Esq.

Material examined. Fifteen workers and a damaged female.

Type locality. Mt. Lofty, South Australia.

STIGMACROS (CYRTOSTIGMACROS) CLIVISPINA Forel, figs. 155-161.

Acantholepis (*Acrostigma*) *clivispina* Forel, Rev. Suisse Zool., 10, p.482, 1902 ♀

Acantholepis (*stigmacros*) *clivispina* Forel, Ann. Soc. Ent. Belg., 49, p.179, 1905 ♀

Stigmacros clivispina Emery, Gen. Insect. fasc., 183, p.34, 1925 ♀

Worker. Length 2·7-3·2 mm. Deep reddish brown with mandibles, antennae and legs lighter; some examples vary to the very dark brown of Forel's description.

Head smooth, except for occipital region, which is very faintly and densely reticulate; scapes and thorax subopaque, irregularly and microscopically reticulate, epinotal declivity transversely striate finely, gaster smooth and shining.

Hair yellowish, very sparse, confined to front of head and apex of gaster; pubescence yellow, dense, fine, adpressed on funiculus but on rest of body very sparse short and suberect.

Head one-fifth longer than broad, slightly broader behind than in front, sides feebly convex, occipital border almost straight, posterior corners rounded; mandibles with five small sharp teeth; clypeus rounded above, carinated, anterior

border rounded and entire; frontal area semicircular, distinct, posterior border faint; frontal carinae straight, diverging very slightly behind; scapes extend beyond occipital border by a third; first segment of funiculus as long as the two following; second to fourth equal, very slightly longer than broad, rest twice as long as broad, apical longer than two preceding; eyes moderately large, slightly convex, placed just behind the middle of the sides.

Pronotum more than twice as broad as long with anterior border and sides feebly convex, dorsum feebly depressed in the middle, anterior angles rather abrupt; mesonotum slightly longer than broad, broader in front than behind; meso-metanotal suture indicated merely by a transverse depression; metanotum slightly elevated with faint stigmata; meta-epinotal suture deep; epinotum rectangular nearly twice as broad as long, marginate, the posterior corners sharp, the dorsum concave. In profile pro-mesonotum flatly and evenly convex with a slight depression at the pro-mesonotal suture; metanotum elevated as a small hump; the anterior third of dorsum of epinotum is sloping, the remaining two-thirds flat and horizontal and half as long as the feebly concave declivity; stigma-bearing spines on upper third of declivity small, sharp, directed backwards and slightly upwards.

Node reduced to a straight line with upper surface deeply concave in centre. In profile thin, almost as high as the dorsum of epinotum, anterior border feebly convex meeting the straight posterior border at a sharp point; on each side near the base a very small hardly noticeable tooth, directed outwards. Legs rather slender.

Female. Length 4-4·5 mm. Colour and pilosity as in worker.

Head smooth, pronotum feebly reticulate, mesonotum and scutellum smooth, epinotum finely reticulate.

Head as broad as long, broader behind than in front, sides feebly convex, posterior border straight; clypeus not carinate; frontal carinae short; scape extends beyond the occipital border by a quarter; eyes large, convex, placed at middle of the sides; ocelli distinct.

Pronotum short, hardly noticeable from above, sides almost straight, anterior angles abrupt; mesonotum large, broader than long with parapsidal furrows deeply impressed; scutellum large, broader than long, between it and the epinotum is a very broad suture. Epinotum almost four times as broad as long, a little broader in front than behind, anterior border feebly concave, sides and posterior border feebly convex, dorsum depressed slightly in the middle. In profile pronotum almost vertical, rest of thorax flat and almost horizontal; dorsum of epinotum feebly convex, rounded into the sloping declivity, which is four times as long as the dorsum; upper third on each side is a stout sharp stigma-bearing spine directed backwards and upwards.

Node reduced to a transverse line, concave in middle. In profile thin as high as dorsum of epinotum without teeth on the sides. Legs short and robust.

Male. Length 1·8-2 mm. Head, thorax, antennae and legs brownish yellow; node and gaster dark brown.

Sculpture of worker but somewhat finer.

Head broader than long with sides and posterior border feebly convex; mandibles small with three reddish small sharp teeth; clypeus not carinated, rounded above and in front; frontal area semicircular, distinct, frontal carinae short, diverging slightly; scape extends beyond the occipital border by a quarter; first segment of funiculus as long as the two following, second to fourth slightly

longer than broad, fifth a little shorter, sixth to tenth equal and slightly longer than broad, apical as long as the two preceding; eyes large, hemispherical, placed just behind the middle of the sides; ocelli clear and distinct.

Pronotum not noticeable from above; mesonotum large, slightly broader than long, parapsidal furrows impressed; scutellum broader than long, broader in front than behind, between it and the epinotum is a broad suture; epinotum from above sloping so that it is difficult to distinguish dorsum and declivity; the epinotal declivity appears to have no spines. In profile pronotum vertical meso-notum convex in front; posterior half of scutellum rather flat; epinotum convex.

Node almost three times broader than long with anterior border and sides convex; posterior border almost straight. In profile rather stout, anterior border and dorsum convex, posterior border straight. Legs slender.

Material examined. Large number of workers and a few males and females.

Collected by Dr. Wheeler at Darra, Queensland, and Canberra, Australian Capital Territory.

Type locality. Cooma, New South Wales.

Type. Worker in Forel's collection, Museum Natural History, Geneva.

STIGMACROS (CYRTOSTIGMACROS) EXTREMINIGRA sp. nov., figs. 162-164.

Worker. Length 2-2·2 mm. Head and gaster black, thorax, legs and antennae dark brown; mandibles yellowish.

Head and gaster smooth with traces of reticulation on back of head. Thorax shagreened.

Hair greyish, confined to front of head and apex of gaster.

Head slightly longer than broad, broader behind than in front, sides feebly convex, occipital border almost straight, posterior corners rounded; mandibles with four small sharp teeth; clypeus rounded in front, faintly carinated on anterior half; frontal area semicircular, distinct; frontal carinae straight as long as distance apart; scape extends beyond the occipital border by a third; first segment of funiculus as long as two following, second to fifth as long as broad, rest longer than broad, apical as long as two preceding; eyes convex, placed just behind the middle of the sides.

Pronotum three times as broad as long, with anterior border and sides feebly convex, anterior corners rounded; mesonotum as broad as long, broader in front than behind, sides almost straight; meso-metanotal suture very faint; metanotum raised with two distinct stigmata; meta-epinotal suture broad; epinotum one and a quarter time as broad as long, sides and posterior border straight, posterior corners rounded. In profile pronotum convex; mesonotum feebly convex; metanotum hump-shaped; epinotum sloping on anterior third with rest of dorsum straight and half as long as the straight declivity.

Node reduced to a transverse line with anterior border feebly convex, the posterior border straight, the dorsum concave in middle. In profile thin, the anterior feebly convex border meeting the straight posterior border at a point. There are no spines on the sides. Legs slender.

Male and *female* unknown.

Collected by J. Clark, Esq.

Material examined. Fourteen workers that show little variation.

Type locality. Wyperfeld, Victoria.

STIGMACROS (CYRTOSTIGMACROS) CASTANEA sp. nov., figs. 165-170.

Worker. Length 2·3-2·6 mm. Head shining dark reddish brown, with mandibles and scapes yellow, funiculus brown; thorax and legs yellowish brown with epinotum and node slightly darker; gaster dark reddish brown.

Head smooth and shining; thorax and node very finely shagreened, rather transverse on epinotum, lower parts of sides of mesonotum and epinotum microscopically reticulate.

Hair yellowish, vary sparse, confined to clypeus and apex of gaster; pubescence whitish, short, fine, adpressed, confined to the funiculus.

Head slightly longer than broad, sides convex, occipital border straight, posterior angles rounded; mandibles with five small sharp teeth; clypeus carinated, anterior border rounded; frontal area semicircular, distinct; frontal carinae straight, diverging slightly behind; scape extends beyond the occipital border by a third; first segment as long as the two following, second shorter than the third, third and fourth sub-equal, slightly longer than broad, remaining segments longer than broad, apical as long as the two preceding; eyes large, convex, placed slightly behind the middle of the sides.

Pronotum about two and a quarter times as broad as long, sides convex, anterior border feebly convex, anterior corners rounded, middle of dorsum not depressed, mesonotum slightly longer than broad, broader in front than behind, sides almost straight; mesometanotal suture obsolete, indicated by a slight transverse depression; metanotum very short, elevated with two distinct stigmata; meta-epinotal suture deep and broad; epinotum one and a quarter times as broad as long, broader in front than behind, with sides and posterior border almost straight; stigma bearing spines on the declivity as long as broad at base, sharp, directed backwards and slightly upwards and outwards. In profile anterior half of pronotum vertical and slightly concave, posterior half rather flat; mesonotum evenly and feebly convex; metanotum raised as a small hump; anterior third of dorsum of epinotum almost vertical, rest of dorsum flat and horizontal, posterior corners rounded, dorsum slightly less than half the feebly concave declivity; spines at upper third sharp, directed backwards and slightly upwards.

Node short and transverse, with dorsum deeply concave. In profile node thin, anterior feebly convex border meeting the straight posterior border at a sharp point. Legs rather slender.

Female. Length 4·3 mm. Rich, reddish brown with legs, pronotum and front of head lighter, antennae darker brown, gaster very dark reddish brown.

Pronotum shagreened, mesonotum and scutellum smooth, epinotum very densely microscopically reticulate-punctate, sides of epinotum very finely transversely striate.

Head similar to that of worker but proportionately broader, as broad as long; clypeus more distinctly carinate; scapes extend beyond the occipital border by about a fifth; eyes larger; ocelli clear distinct, whitish.

Pronotum from above short and concealed by the mesonotum; mesonotum large, as broad as long, with parapsidal furrows impressed; scutellum large; broader than long, broader in front than behind, between it and the epinotum is a broad suture; epinotum at least four times as broad as long, broader in front than behind, anterior border concave, sides almost straight, posterior border straight, posterior angles blunt, the dorsum concave. In profile pronotum almost vertical, anterior quarter of mesonotum convex, rest of thorax flattened

and almost horizontal; dorsum of epinotum straight, about a quarter as long as sloping declivity; at the upper quarter of declivity the stigma bearing spines are small, stout directed backwards and slightly upwards.

Node reduced almost to a transverse line, with dorsum feebly concave. In profile almost as high as the dorsum of epinotum, thin, anterior very feebly convex border meeting the straight posterior border at a sharp point; near the base on each side there is a trace of a small tooth. Legs slender.

Male. Length 1·8 mm. Uniformly dull yellowish brown.

Head smooth with faint traces of reticulation on occipital border, thorax very faintly reticulate, sides finely reticulate with base of mesonotum and epinotum more striate transversely; node reticulate.

Hair yellowish, confined to clypeus and apex of gaster; pubescence yellowish, short, confined to funiculus.

Head as broad as long, with convex sides and almost straight occipital border; clypeus rounded in front, not carinated; frontal area semicircular, distinct; frontal carinae long and almost straight; scapes extend beyond the occipital border by a third; first segment as long as the two following, second shorter than third, rest longer than broad, apical almost as long as the two preceding together; eyes large, hemispherical, placed at centre of sides; ocelli distinct.

Pronotum short, almost concealed by the mesonotum; mesonotum large, broader than long, parapsidal furrows impressed; scutellum large, broader than long, broader in front than behind; metanotum transverse, raised slightly; epinotum broader than long, broader in front than behind, posterior border almost straight. In profile pronotum vertical; mesonotum vertical in front, posterior three-quarters convex; scutellum and metanotum feebly convex; epinotum feebly convex, rounded into the sloping declivity which is about three times as long as the dorsum.

Node three times as broad as long, anterior border and sides feebly convex, posterior border almost straight. In profile as high as epinotum, three times as high as long with borders feebly convex. Legs long and slender.

Collected by Dr. W. M. Wheeler.

Material examined. Thirty workers, five males and one female.

Type locality. Canberra, Australian Capital Territory.

STIGMACROS (CYRTOSTIGMACROS) ACICULATA sp. nov., figs. 171-173.

Worker. Length 2·5 mm. Rich reddish brown with legs lighter and antennae dull yellow.

Head smooth except for the occipital border which is faintly shagreened; thorax densely reticulate punctate; gaster smooth. Hair yellowish, confined to front of head and apex of gaster.

Head very slightly longer than broad, hardly broader behind than in front, sides and occipital border almost straight, posterior corners rounded; mandibles with four small sharp teeth; clypeus not carinated, rounded above and in front, frontal area semicircular, distinct; frontal carinae straight as long as their distance apart; scape extends beyond the occipital border by two-fifths; first segment of funiculus as long as the two following, second to fourth equal, as broad as long, rest longer than broad, apical as long as preceding two; eyes convex, placed behind the middle of sides.

Pronotum three times as broad as long, sides and anterior border feebly convex, anterior corners abruptly rounded; mesonotum as broad as long, broader in front than behind, sides almost straight; meso-metanotal suture very faint;

metanotum raised; stigmata distinct; meta-epinotal suture broad; epinotum one and a quarter times as broad as long, very slightly broader in front than behind, sides feebly convex, posterior border feebly concave, posterior corners blunt, dorsum concave. In profile pronotum convex in front, posterior half rather flat; mesonotum feebly convex; metanotum raised as a small hump; epinotum sloping in front, posterior two-thirds straight and one-third as long as the feebly concave declivity, posterior corners sharp; at upper third the spines are sharp and directed upwards and backwards.

Node reduced to a transverse line, anterior border feebly convex, posterior border straight, dorsum concave in middle. In profile scale-like, anterior feebly convex border meeting the feebly concave posterior face at a point. Legs robust.

Male and *female* unknown.

Collected by H. Hacker, Esq.

Material examined. Seventeen workers.

Type locality. Brisbane, Queensland.

STIGMACROS (CYRTOSTIGMACROS) PROXIMA sp. nov., figs. 174-176.

Worker. Length 2·2-2·7 mm. Yellowish brown, antennae and legs yellowish.

Head smooth and shining; thorax finely shagreened with sides densely microscopically reticulate punctate; gaster smooth. Hair yellowish, short, very scattered; pubescence yellowish, confined to funiculus.

Head slightly longer than broad, sides feebly convex, occipital border almost straight, posterior angles rounded; mandibles yellowish, with five small sharp teeth; clypeus not carinated, rounded above and in front; frontal area semicircular, posterior border not indicated; frontal carinae straight, diverging very slightly behind; scapes extend beyond the occipital border by almost a quarter; first segment as long as the two following, second shorter than the third, third to ninth almost equal in length, longer than broad and increasing slightly in width, apical segment not quite as long as the two preceding; eyes convex, moderately large, placed just behind the middle of the sides.

Pronotum twice as broad as long, sides and anterior border feebly convex, anterior angles abruptly rounded; mesonotum broad as long; meso-metanotal suture faint; metanotum elevated, with distinct stigmata; meta-epinotal suture deep; epinotum one and a fifth times as broad as long, slightly broader in front than behind, sides margined and straight, posterior border almost straight, dorsum concave. In profile anterior half of pronotum concave, posterior half rather flatly convex; mesonotum convex; metanotum raised as a small hump; epinotum convex about one-third as long as the feebly concave declivity; spines on declivity sharp, slender, longer than broad at the base, placed just above the centre.

Node reduced to a transverse line, anterior border feebly convex, posterior border straight, dorsum concave in middle. In profile very thin, anterior feebly convex border meeting the straight posterior border at a sharp point. Near the base on each side is a sharp tooth directed outwards. Legs long, robust.

Male and *female* unknown.

Collected by W. M. Mann, Esq.

Material examined. Four workers.

Type locality. Athol, New South Wales.

STIGMACROS (CYRTOSTIGMACROS) SORDIDA sp. nov., figs. 177-179.

Worker. Length 2 mm. Dull yellowish brown with antennae, thorax and legs slightly lighter, mandibles yellowish.

Head and gaster smooth, thorax very finely shagreened.

Hair yellowish confined to front of head and apex of gaster.

Head slightly longer than broad, sides and occipital border feebly convex, posterior corners rounded; mandibles with four small teeth; clypeus large, not carinated, rounded in front; frontal area semicircular, faint; frontal carinae almost straight; scape extends beyond occipital border by a third; first segment as long as the following two, second to sixth as broad as long, seventh to ninth longer than broad, apical as long as preceding two; eyes moderately large, convex, placed just behind middle of sides of head.

Pronotum three times as broad as long, sides almost straight, anterior border feebly convex, anterior angles rather abrupt, mesonotum as broad as long, broader in front than behind, sides almost straight; meso-metanotal suture feebly indicated; metanotum raised, distinct stigmata; epinotum one and a quarter times as broad as long, almost as broad behind as in front, sides straight, posterior border feebly concave, corners blunt, dorsum concave. In profile pronotum feebly convex; mesonotum rather flat, metanotum hump-shaped; anterior third of epinotum straight and sloping, posterior two-thirds straight, elevated behind, one-third of feebly concave declivity; at upper third are sharp broad spines directed backwards and upwards.

Node reduced to a transverse line, concave in middle. In profile thin, anterior convex border meeting the slightly concave posterior border at a point; very tiny teeth at base on each side. Legs slender.

Male and *female* unknown.

Collected by W. Pennifold, Esq.

Material examined. Fourteen workers.

Type locality. Adelaide, South Australia.

STIGMACROS (CYRTOSTIGMACROS) ARMSTRONGI sp. nov., figs. 180-183.

Worker. Length 2·5-2·8 mm. Dull brownish yellow with head darker and gaster more or less infuscated; antennae yellow. Some have the head and gaster dark reddish brown and the thorax yellowish.

Head smooth with faint reticulation on the occiput; thorax smooth in centre, elsewhere very faintly shagreened; gaster smooth.

Hair yellowish, very sparse, confined to mandibles, clypeus and apex of gaster; pubescence yellowish, fine, adpressed, confined to funiculus.

Head one-sixth longer than broad, sides feebly convex, occipital border almost straight, posterior angles rounded; mandibles with five small sharp teeth; clypeus not carinated, anterior border rounded; frontal area semicircular, defined clearly; frontal carinae short, straight, diverging slightly behind; scapes extend beyond occipital border by a quarter; first segment as long as the two following, second to fourth equal, fifth to eighth distinctly longer than broad, ninth as long as broad, apical as long as the two preceding; eyes moderately large, convex, placed slightly behind the middle of the sides.

Pronotum twice as broad as long, slightly flattened above, anterior border and sides feebly convex, anterior angles rounded; mesonotum as long as broad, broader in front than behind, sides almost straight; meso-metanotal suture not indicated; metanotum raised with distinct stigmata; meta-epinotal suture broad; epinotum one and a quarter time as broad as long, very slightly broader in front than behind, sides and posterior border feebly concave, posterior angles rather sharp. In profile promesonotum rather flat, very slightly convex, metanotum indicated by a small hump; dorsum of epinotum flat and horizontal, elevated very slightly at posterior angle, half as long as very feebly concave declivity, posterior angle almost a right angle; spines just above middle of declivity sharp, directed backwards and upwards.

Node almost reduced to a transverse line, anterior border feebly convex, posterior border straight, dorsum deeply concave. In profile thin with feebly convex anterior border meeting the straight posterior border at a sharp point. On each side near the base is a very small tooth directed outwards. Legs slender.

Female. Length 5·2 mm. Dark brown or black, antennae, mandibles and legs lighter more reddish brown.

Head very faintly shagreened, thorax and node finely shagreened, gaster smooth.

Head as broad as long, sides and posterior border almost straight, posterior corners rounded; mandibles with four teeth; clypeus strongly carinated; scape extends beyond occipital border by a fifth; eyes large, convex, placed at middle of sides; ocelli small but distinct, whitish.

Pronotum from above short, almost concealed by mesonotum, anterior border feebly convex, sides almost straight, anterior corners abrupt; mesonotum large, as broad as long, parapsidal furrows impressed; scutellum large, broader than long, broader in front than behind; epinotum almost four times as broad as long, broader in front than behind, anterior border concave, sides feebly convex, posterior border feebly concave. In profile pronotum vertical; mesonotum and scutellum form one even rather low convexity; dorsum of epinotum feebly convex; almost one-quarter as long as the straight declivity; at upper quarter on each side is a moderately long, stout, blunt spine.

Node reduced to a transverse line. In profile thin, anterior and posterior borders feebly convex, meeting at a point. Gaster large. Legs short and robust.

Male unknown.

Collected by J. W. T. Armstrong, Esq.

Material examined. Eighteen workers and one female.

Type locality. Nyngan, New South Wales.

STIGMACROS MEDIORETICULATA Viehmeyer.

Acantholepis (Stigmacros) medioreticulata Viehmeyer, Ent. Mitteil., 14, nr.I., p.32, 1925 ☿

Worker.

Kopf kurz eiformig, wenig langer als breit, hinter deutlich breiter als vorn, Hinterrand gerade. Clipeus schwach gekielt, sein Vorderrand sehr flach ausgerandet, von oben gesehn durch den Kiel aber dreieckig erscheinend. Augen ein wenig hinter der mitte der Kopfseiten, Stirnfeld undeutlich. Der Fuhlerschaft oberragt den Hinterrand des Kopfes um ein gutes Drittel seiner Lange; die mittleren Fuhlerglieder fast doppelt so lang wie breit. Thorax etwas flach

gedruckt, aber bei weitem nicht so wie bei *aemula* und *pilosella*, auch nicht so breit. Pronotum wesentlich schmaler als der Koft, trapezformig, weit uber doppelt so breit als lang, vorn etwas steil abfallend, mit augedeuteten Schultern, in der mitte mit einem breiten Laugseindruck. Mesonotum langer als breit. Stiel nicht gerandet, beiderseits hinten mit schwach aufgebogenen, zahnformigen Echen. Kein abgegrenztes Metanotum, an seiner Stelle ein breiter Einschnitt zwischen Meso und Epinotum; Basalfache des Epinotums im Profil querrechtechtig mit erhabenen, scharfen Seitenrandern, jederseits langs derselben leicht vertieft, im Profil schrag ansteigend. Epinotumwinkel fast ein rechter. Abschussige Flache fast dreimal so lang als die Basal flache, sehr schrag und etwas konkav, in 2/3 ihrer Hohe mit den beiden stigmentragenden, spitzen Zahnen. Schuppe mit scharfem, in der mitte tief dreieckig ausgeschnittenem Rande; Basalzahne des Seitenrandes rudimentar. Thorax scharf genetztkaum schimmernd, glieder sehr seicht genetzt, Kopf und gaster spiegelnd glatt. Pubeszenz sehr kurz und sehr zerstreut, an den Gliedern reichlicher, keine abstehande Behaarung. Kopf und Gaster tief schwarz, Thorax und Beine schwarzbraun, Mandibeln, Fuhler, Trochanteren, Knie und Tarsen rotlich braun. L. 2·5 mm. Trial Bay.

I Stuck aus Brennholz. Anscheinend mit *clivispina* zunachst verwandt, aber mit viel langeren Geisselgliedern und ohne Metanotum.

Subfamily FORMICINAE Lepeletier, 1863.

Tribe LASIINI Ashmead, 1905.

Genus TERATOMYRMEX gen. nov.

Worker. Monomorphic.

Head almost square with broad triangular mandibles furnished with five small sharp teeth. Maxillary palpi with four slender, equal segments. Labial palpi with two slender, equal segments. Clypeus rather large, anterior border entire, posterior border rounded and not extending back between the frontal carinae. Frontal area subtriangular, distinct. Frontal carinae, short and straight. Antennal and clypeal fossae not confluent, but antennae placed close to the clypeus. Antennae twelve segmented, funiculus filiform, with first segment as long as two following, remaining segments longer than broad, apical longer than preceding segment. Eyes moderately large, convex. Ocelli distinct.

Thorax of most unusual shape. Dorsum of pronotum very flattened, margined. This flattened surface is about three times as broad as long, the anterior and posterior borders deeply concave, the sides strongly convex, the corners rounded. The sides of the pronotum slope inwards and can be seen only in the profile view. The mesonotum resembles a cylinder which fits under the posterior raised lip of the pronotum, and is about a third as broad as the pronotum. Metanotum slightly broader than mesonotum and surmounted by two distinct spiracular tubercles. The dorsum of epinotum resembles a wide-necked flask, the anterior half circular, the posterior half is narrowed, with parallel sides, the posterior corners produced as broad sharp teeth. The posterior border, between these teeth deeply concave. Petiole surmounted by an erect scale-like node which is greatly narrowed at the top. It bears no spines. Gaster not overhanging petiole, ovate, with the cloacal orifice surrounded by a fringe of hairs. Legs moderately long, middle and hind tibiae with pectinate spurs, tarsal claws simple.

Female and *male* unknown.

Genotype *Teratomyrmex greavesi* sp. nov.

TERATOMYRMEX GREAVESI sp. nov., figs. 1-3.

Worker. Length 3-3·5 mm. Very dark brown to shining black, antennae and legs dull yellowish brown, coxae and insertions of scapes yellowish.

Mandibles smooth and shining with faint traces of striae; clypeus smooth; head shining with scattered microscopic shallow, piligerous punctures which are denser on occiput and sides of head; pronotum with scattered microscopic piligerous punctures denser than on the head; mesonotum smooth; epinotum with scattered piligerous punctures, the sides and declivity with faint transverse striae; rest smooth.

Hair greyish, scattered and long on mandibles, clypeus, scapes, thorax, node and gaster. Pubescence greyish, adpressed, rather dense especially on the gaster but not hiding the sculpture.

Head excluding the mandibles square with the sides almost straight, the posterior border slightly convex, posterior angles rounded; mandibles triangular furnished with five sharp teeth, the apical and following tooth twice as large as the three following; clypeus rounded above, anterior border entire; frontal area subtriangular, distinct; frontal carinae short, straight, slightly diverging behind; antennal scape extending beyond the occiput by almost half its length; first segment of funiculus as long as two following together, fourth and fifth equal, longer than broad, sixth to tenth longer than broad, apical longer than tenth but not longer than two preceding together.

Dorsum of pronotum very flattened, slightly depressed in the middle, almost as broad as the head, slightly more than three times as broad as long, sides margined, anterior and posterior borders deeply concave, sides strongly convex, posterior corners more sharply rounded than anterior ones, posterior margin slightly raised. Mesonotum cylindrical, one-quarter longer than broad, about one-third narrower than pronotum, sides parallel. Metanotum slightly broader than the mesonotum, surmounted by two spiracular tubercles, metaepinotal suture distinct. Epinotum twice as long as broadest part, anterior half almost circular, but instead of completing the circle the sides extend back as parallel lines which diverge slightly behind and terminate in a short raised broad spine; the posterior border of the epinotum between these spines is strongly concave; the sloping sides of the epinotum allow much of the metathoracic sternites to be seen. In profile anterior border of the pronotum straight, sloping outwards to meet the flattened dorsum at a point; dorsum of pronotum and mesonotum almost flat, the former slightly higher, the sides of the pronotum horizontally concave below the flattened disc of the dorsum. Metanotum raised with the spiracular tubercles very distinct. Dorsum of epinotum straight, raised behind, and terminating in broad sharp spines directed backwards and slightly upwards; under each spine is a clear stigma.

Petiole from above, thin, about three times as broad as long; upper border reduced to a short transverse line deeply concave in the centre. In profile scale-like, three times as high as long, narrowed towards the top, erect, the anterior and posterior faces feebly convex, and meeting at a sharp point. Gaster longer than broad. Legs moderately long.

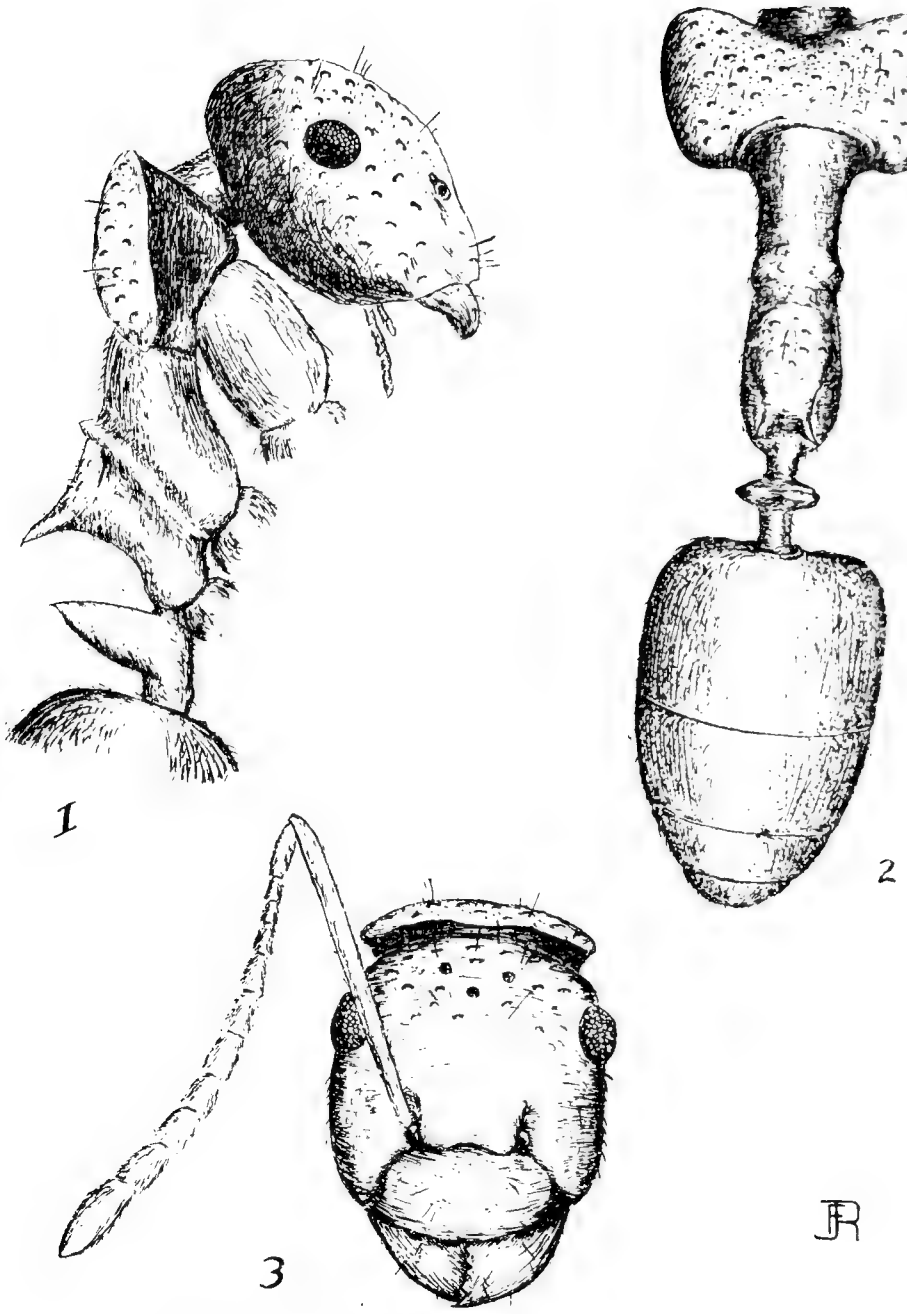
Collected by T. Greaves, Esq.

Type locality. Blackall Range, Queensland.

Material examined. Seven workers which exhibit very little variation.

Type. Holotype worker in collection of National Museum, Victoria.

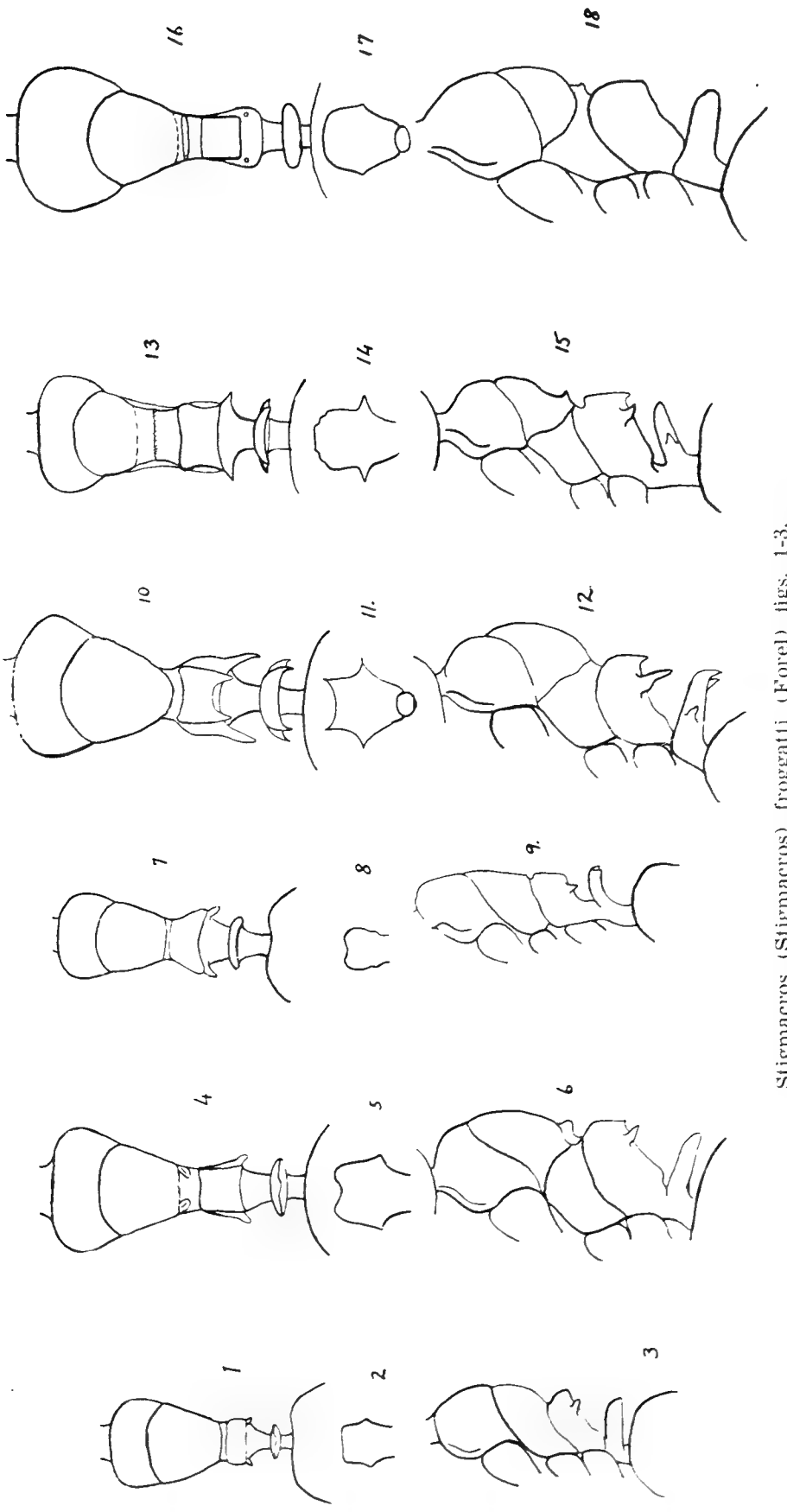
Paratypes in collection of Commonwealth Scientific and Industrial Research Organization, Canberra, and in collection of author.



Teratomyrmex greavesi sp. nov.

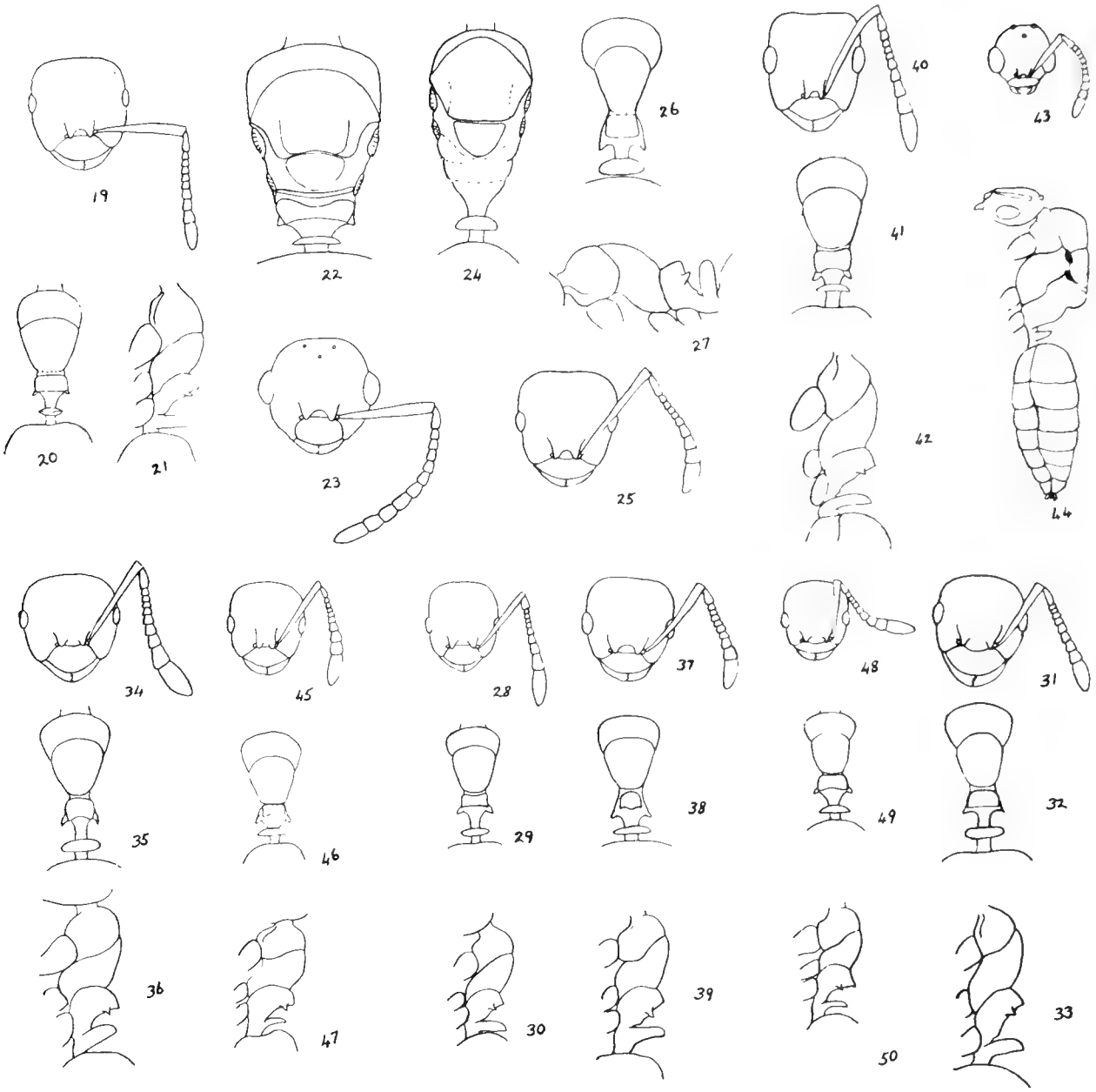
1. Profile view of worker.
2. Dorsal view of thorax and gaster of worker.
3. Head and humeri of worker.

PLATE 1.



Stigmacros (Stigmacros) froggatti (Forel) figs. 1-3.
Stigmacros (Cyrtostigmacros) australis (Forel) figs. 4-6.
Stigmacros (Campostigmacros) aemula (Forel) figs. 7-9.
Stigmacros (Hapiostigmacros) barretti (Santschi) figs. 10-12.
Stigmacros (Chariostigmacros) hirsuta sp. nov. figs. 13-15.
Stigmacros (Pseudostigmacros) inermis sp. nov. figs. 16-18.

PLATE 2.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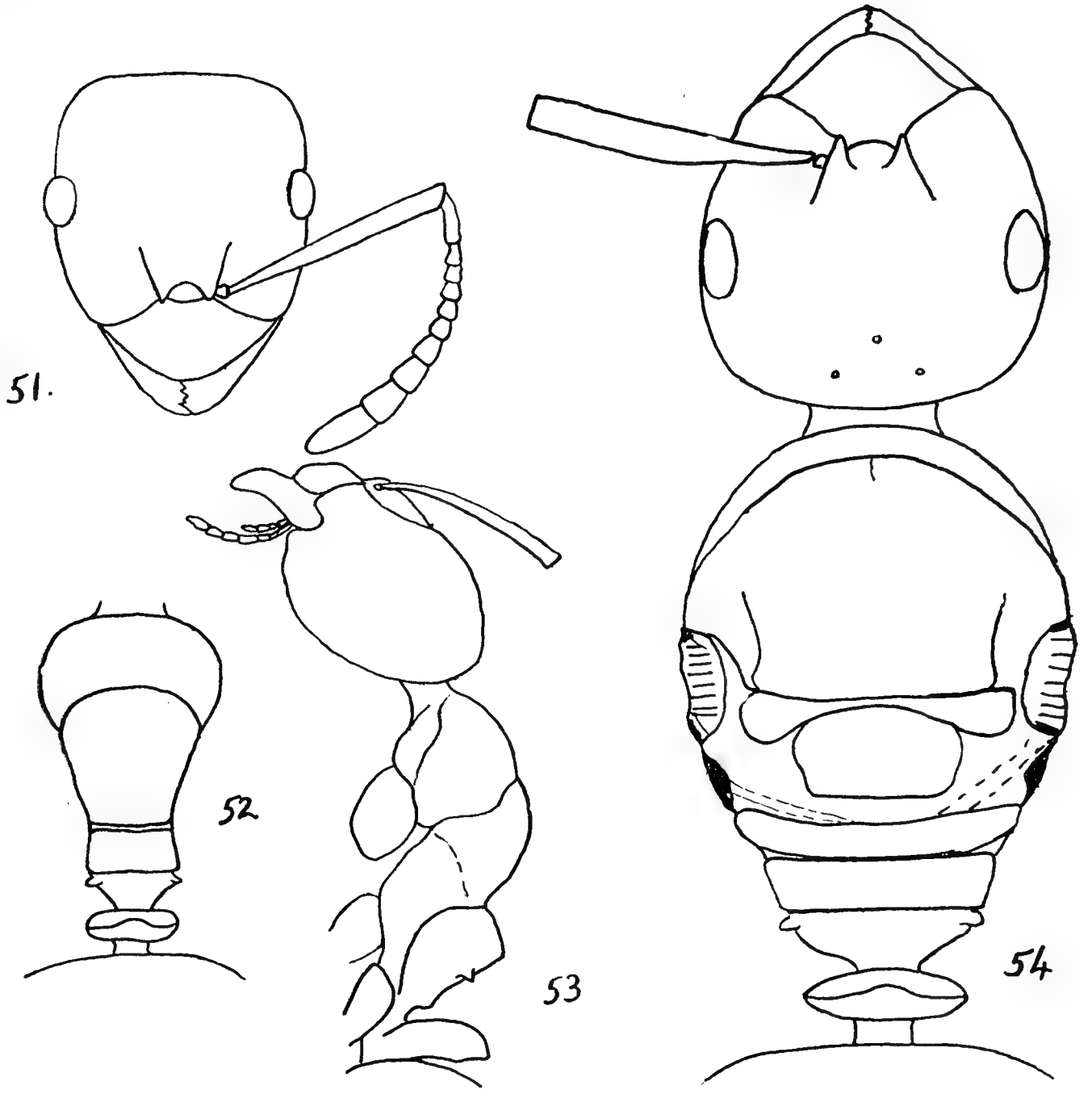

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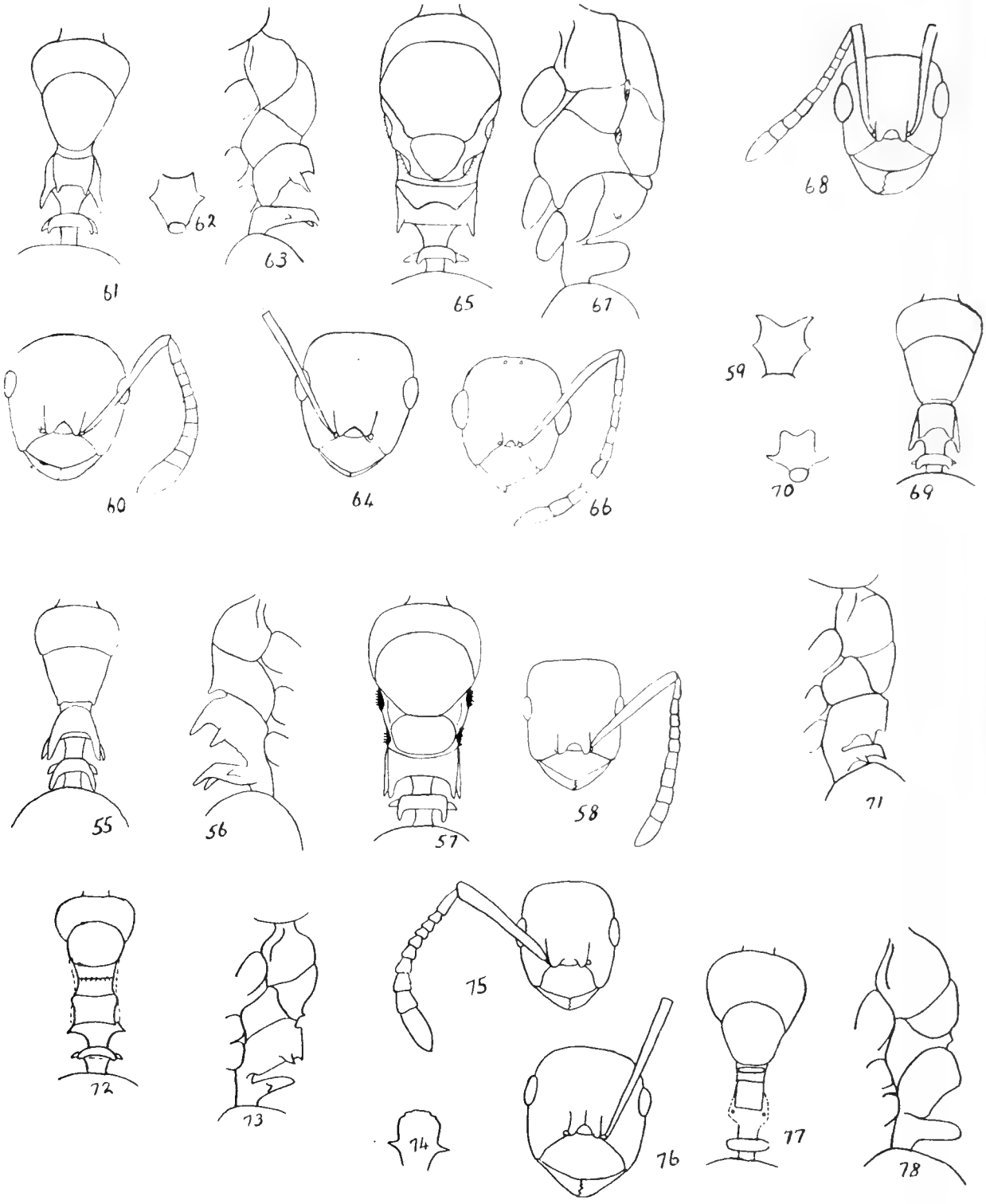

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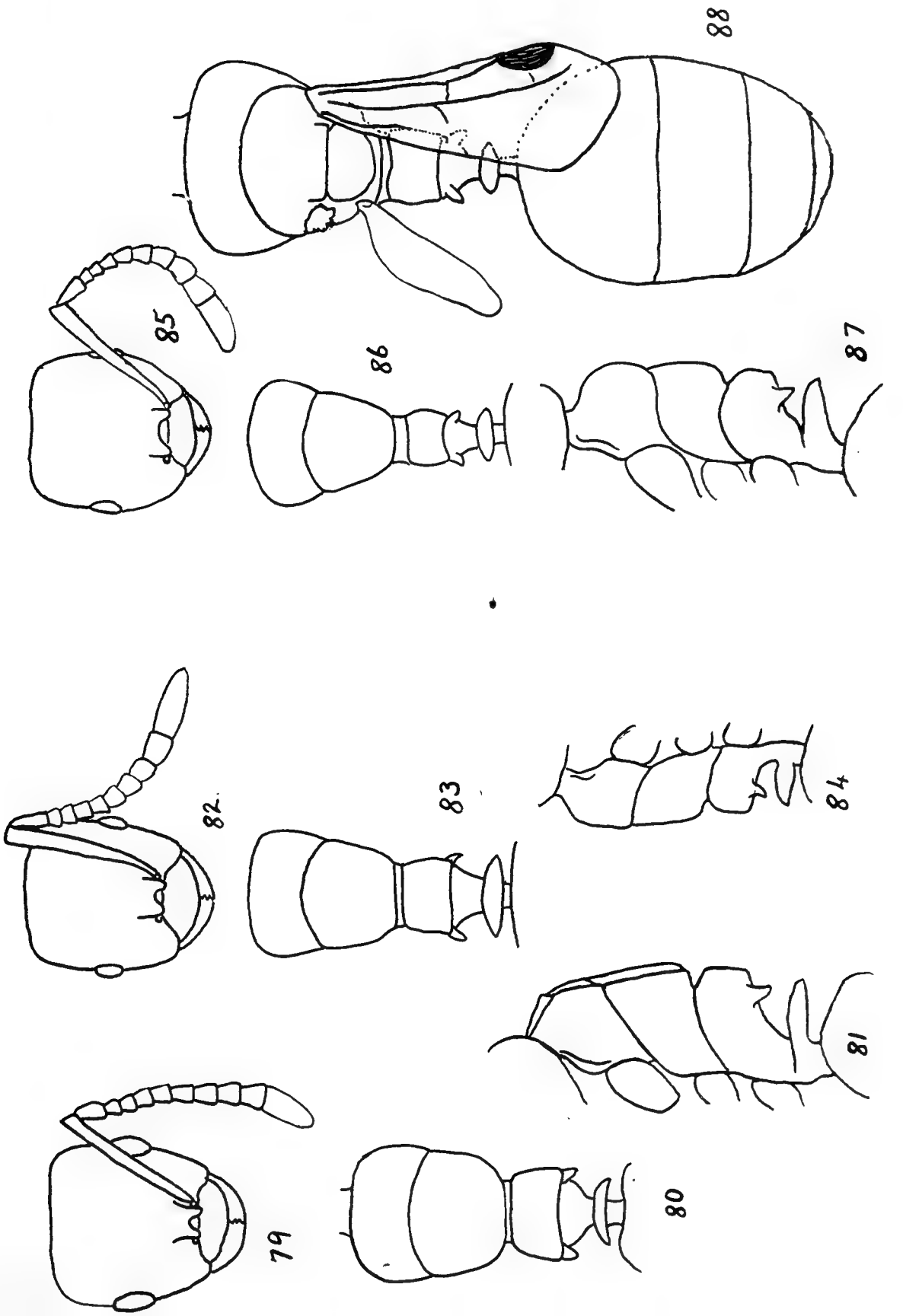

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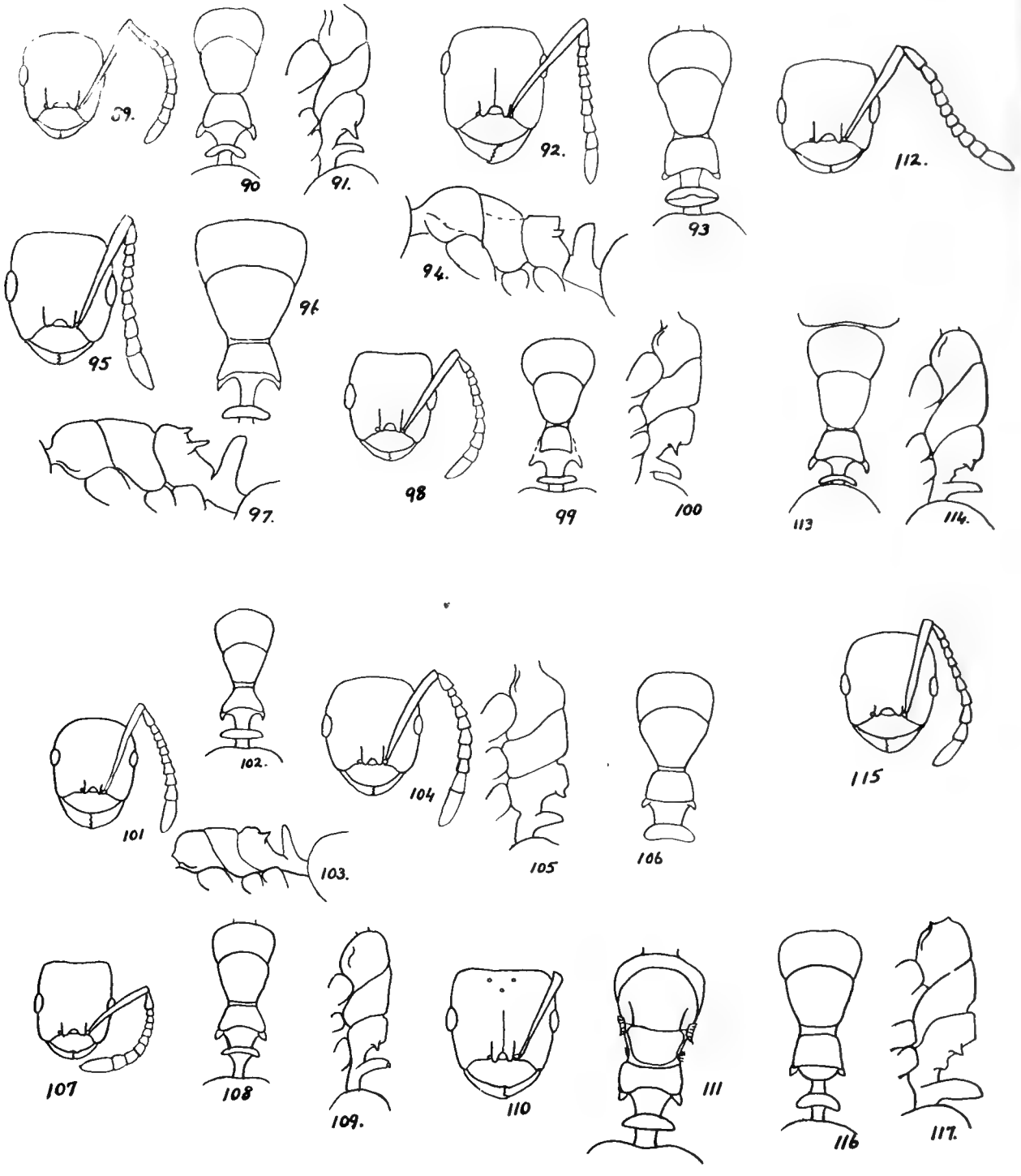
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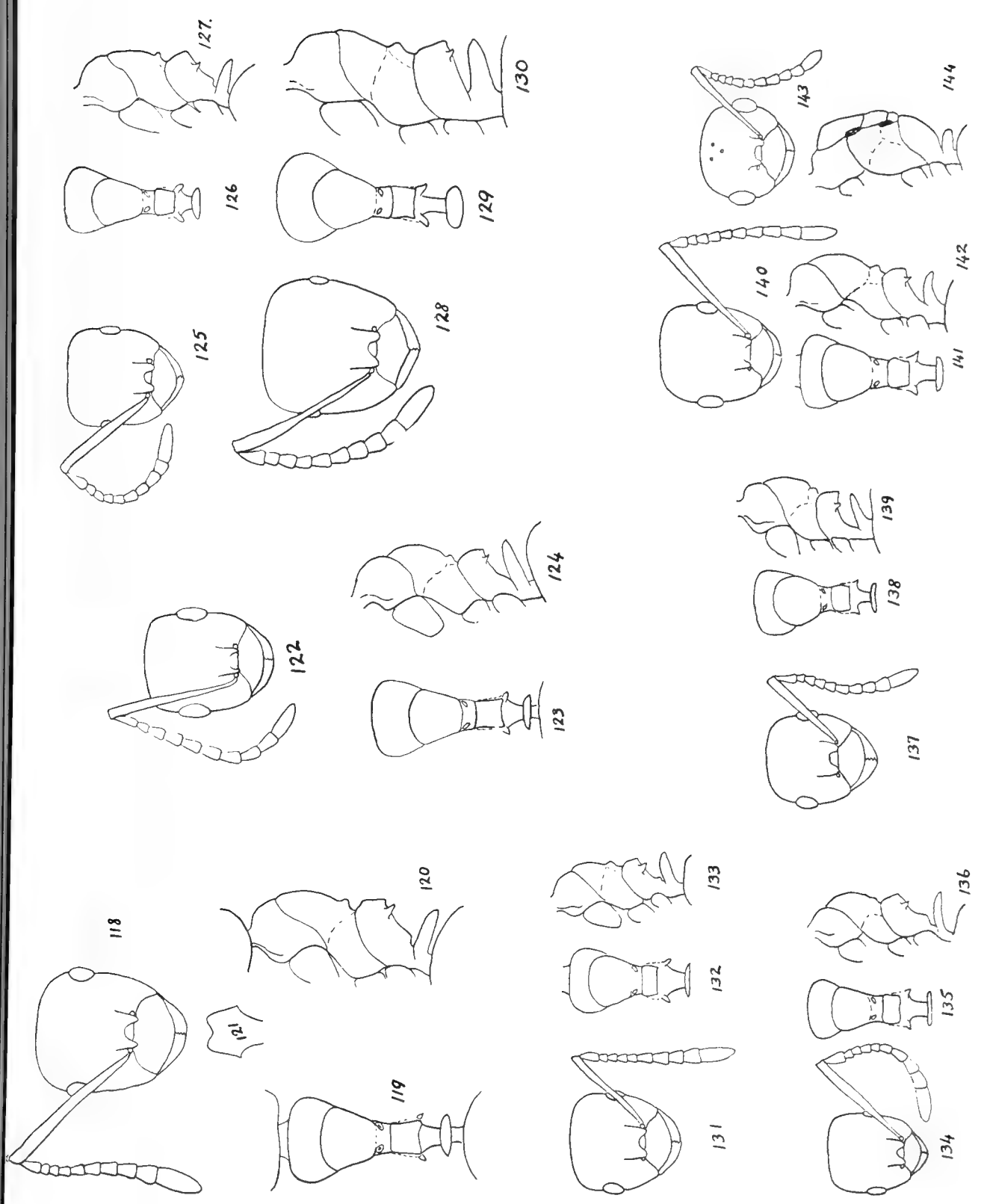
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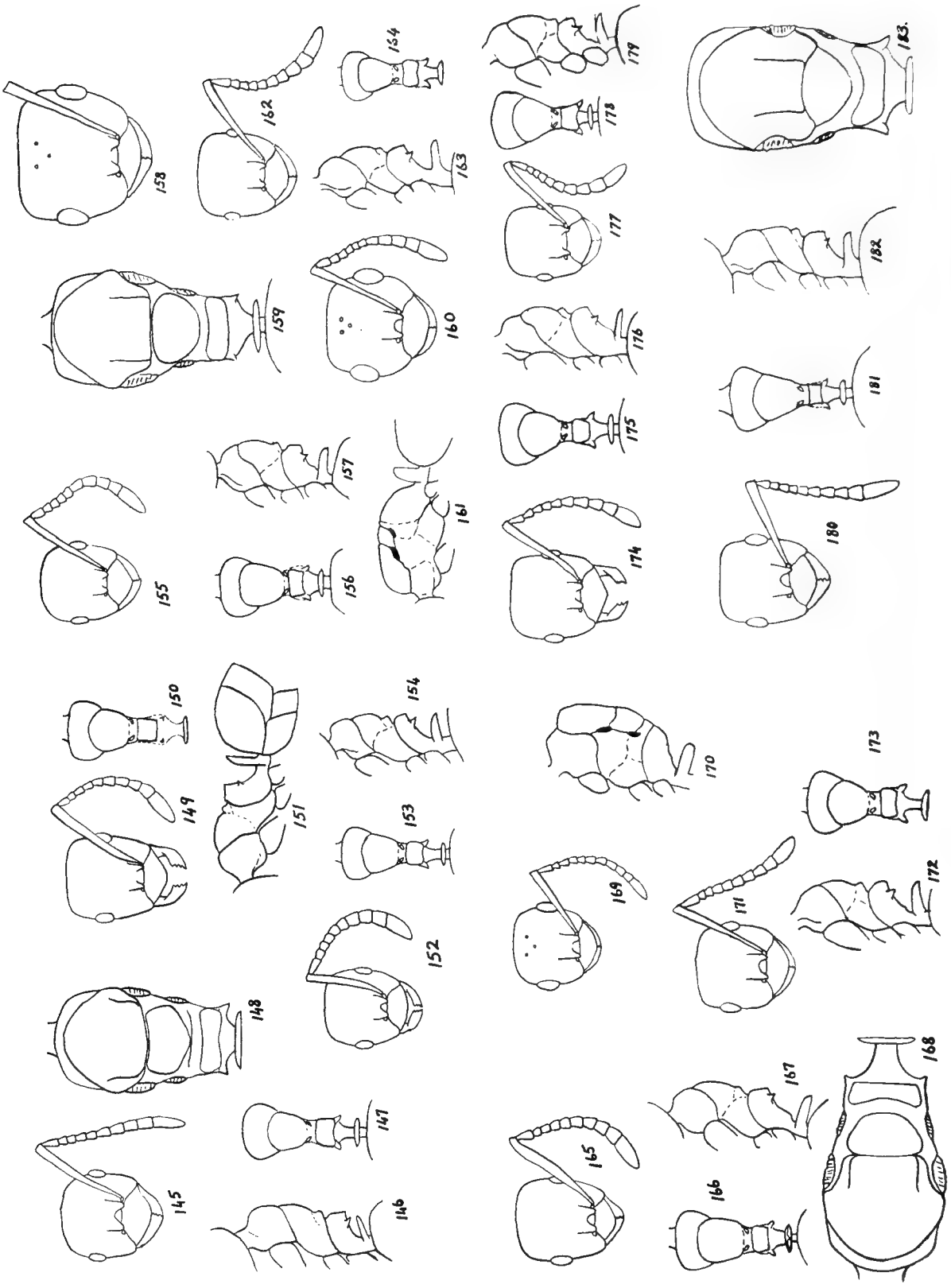
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ABORIGINAL STONE ARTEFACTS FROM THE NORTHERN TERRITORY.

By S. R. Mitchell, Honorary Associate in Ethnology, National Museum of Victoria.

This paper describes some aboriginal stone artefacts collected by the writer in May, 1951 from the Edith River, Northern Territory, an area from which such material has not hitherto been recorded. The Edith River rises in the great plateau east of the railway line, and joins the Ferguson River, a tributary of the Daly River. It is fed by perennial springs, ensuring a constant flow throughout the dry season, (Woolnough, 1912); during the wet period, however, it overflows its banks, flooding much of the surrounding country.

Evidence of aboriginal occupation on the low banks of one of its dry tributaries was indicated by the profusion of broken stone, flakes, cores and the presence of flaked hand-axes. The site is within a mile of Mt. Todd, which is 30 miles south-east of Pine Creek, and 110 miles due south-east of Darwin. The stone from which these artefacts were fashioned is a dense black fine-grained rock identified by Dr. D. E. Thomas, Chief Government Geologist of Victoria, as hornfels. Hard and somewhat brittle, it flakes readily, with a well defined conchoidal fracture. It was obtained from the pre-Cambrian country rock which outcrops in the bed of the Edith River in the form of water-worn boulders. Close to the confluence of this river with a dry tributary are several outcrops where stone has been quarried by the natives.

The collection of artefacts comprises numerous blades and flakes, two spoke-shaves, eighteen flaked and one edge-ground axe. Some of the flakes and blades are up to 120 mm. in length, and from 25 mm. to 55 mm. in width. All show portions of a flat striking platform and a well-defined bulb of percussion, the angle between the striking platform and the inner surface ranging from 100 to 110 degrees. Nine have median ridges (figs. 2, 4, and 5), and are triangular in cross-section; the inner surfaces are plain, with two plain facets on the outer surfaces, and edges more or less sharp. Some of the broader forms have three facets on the outer surface and are trapezoidal in cross-section. Some are lanceolate in shape, and taper from the base to the apex, others have the points broken off (figs. 4 and 5). Most could have functioned as knives, some as spear points. When allowance is made for the marked difference in the material used, they are

similar in form to the quartzite knives and spearpoints described by Spencer and Gillen (1912) and made by the Warramunga people of Central Australia. The edges show little secondary working, but are in some examples finely serrated, seemingly due to use in cutting and sawing hard objects. One leaf-shaped piece (fig. 1) 85 mm. in length, 40 mm. in width, and 15 mm. in thickness, shows definite secondary working along each side margin, and has the appearance of a pirri; the flaking however is more abrupt, and does not continue to the median ridge, and may have been caused by use in scraping. Another leaf-shaped flake is 65 mm. in length, 38 mm. in width at the basal end, with one margin trimmed, possibly by pressure flaking.

Very few examples of scraping tools were found. One large irregularly shaped piece illustrated in fig. 6 is 95 mm. long, 55 mm. wide, and 20 mm. thick; it has marginal trimming on the distal end and the two lateral margins (fig. 5) illustrate an end and side scraper.

Two pieces can be classed as spoke-shaves, evidently used for planing or scraping round wooden objects. One is a long flake-blade, triangular in cross section, 123 mm. long, 43 mm. wide, and 15 mm. high close to the base, tapering to a point. One margin has the original sharp edge, the other a concave edge, 65 mm. long, and 5 mm. deep, with the working edge continued to the distal end. The other example is a thicker flake-blade trapezoidal in cross section, 100 mm. long, 38 mm. wide, and 7 mm. thick. The concave scraping edge on one margin is 75 mm. long, and 4 mm. deep.

The flaked axes, numbering eighteen, fall into three groups. The first comprise those made from rectangular blocks of stone, from which large primary flakes have been expertly detached, reducing it to an ovate or pear-shaped form. Secondary trimming of the margin and particularly of one or both extremities has resulted in more or less sharp cutting edges. Fig. 7 represents this type—it weighs 21 oz., is 140 mm. in length, 80 mm. at its widest part, and 45 mm. in the middle. Viewed from the side, it is bilaterally symmetrical. Each end has a sharp cutting edge.

A modification of this type is illustrated in fig. 8. It has at one end portion of a flat striking platform and has been trimmed to a narrow cutting edge on the distal end.

A second group comprises implements made from massive flakes having one more or less plain surface from which the primary flaking has been effected. One end is trimmed from both

faces to a cutting edge which is usually narrow. This type is bilaterally asymmetrical. One example (fig. 9) is almost a uniface implement, with trimming on one face but little on the other except at the cutting edge. It weighs 16 oz., and is 120 mm. in length, 85 mm. in width, and 200 mm. in thickness.

A third group comprises uniface axes made from massive flakes flat on one face and trimmed from this face only; and have sharp cutting edges on one or both ends. In only one case has a flat river pebble been used.

One edge ground axe was found, made from a dark-grey dioritic type of rock. The cutting edge is much damaged, through subsequent use as a hammer stone. Woolnough records diorite north of the Howley Mine near Brooks Creek, about 70 miles away, which is possibly the source of the stone used for this axe.

One axe sharpening stone was located close to the crossing of the Mt. Todd track, and the Edith River, east of the main highway. It is a large waterworn boulder of hornfels, about 24 in. long, 12 in. wide, and 8 in. deep, with two pronounced sharpening grooves.

It is impossible to say with any degree of certainty whether these flaked axes were hafted or used as hand axes. Some are almost identical in form with the well-known biface axes of the south-eastern portions of South Australia and the Western District of Victoria. Some of the biface axes of the Worora tribe of the north-west of Western Australia are said to have been used as hafted axes without grinding. A flaked axe head was given to the writer by a former resident of Wyndham, Western Australia, who stated that it was originally hafted, a fact confirmed by the presence of gum cement on it. It is a well-shaped axe, flaked from a block of hard stone, with a comparatively crude cutting edge. It weighs 20 ozs., is 128 mm. long, 75 mm. wide, and 43 mm. thick.

ACKNOWLEDGMENT.

I would like to express my thanks to Miss Gwen Walsh, of Adelaide, for her careful and accurate interpretation of the illustrations.

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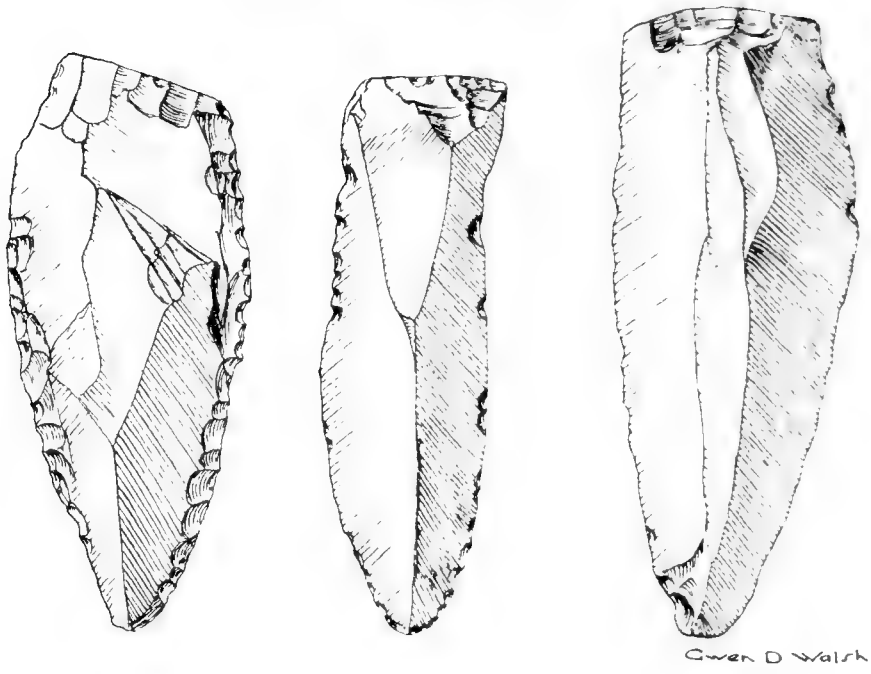

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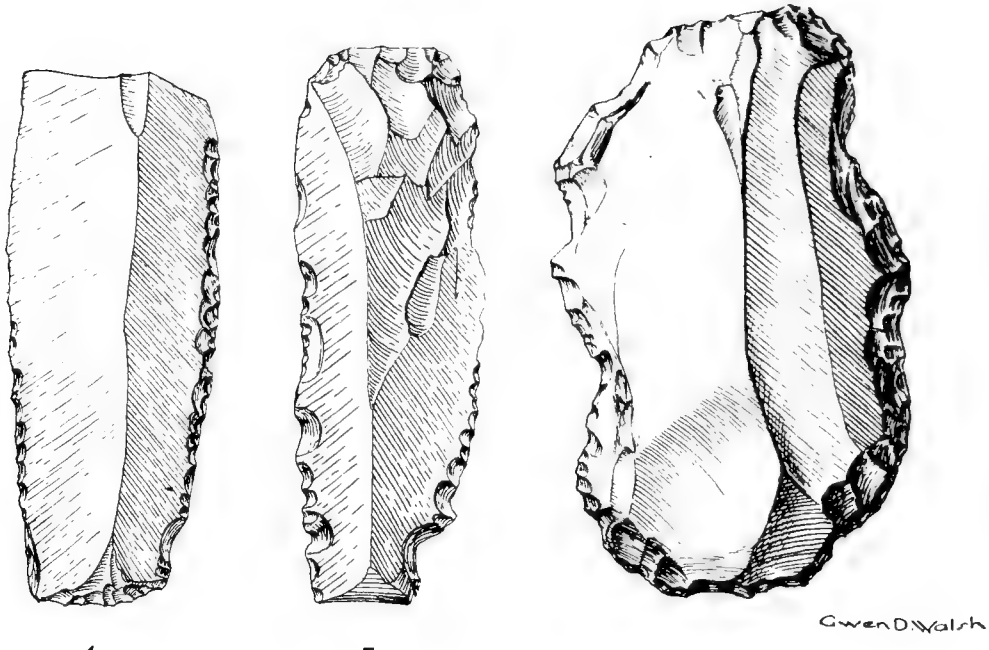

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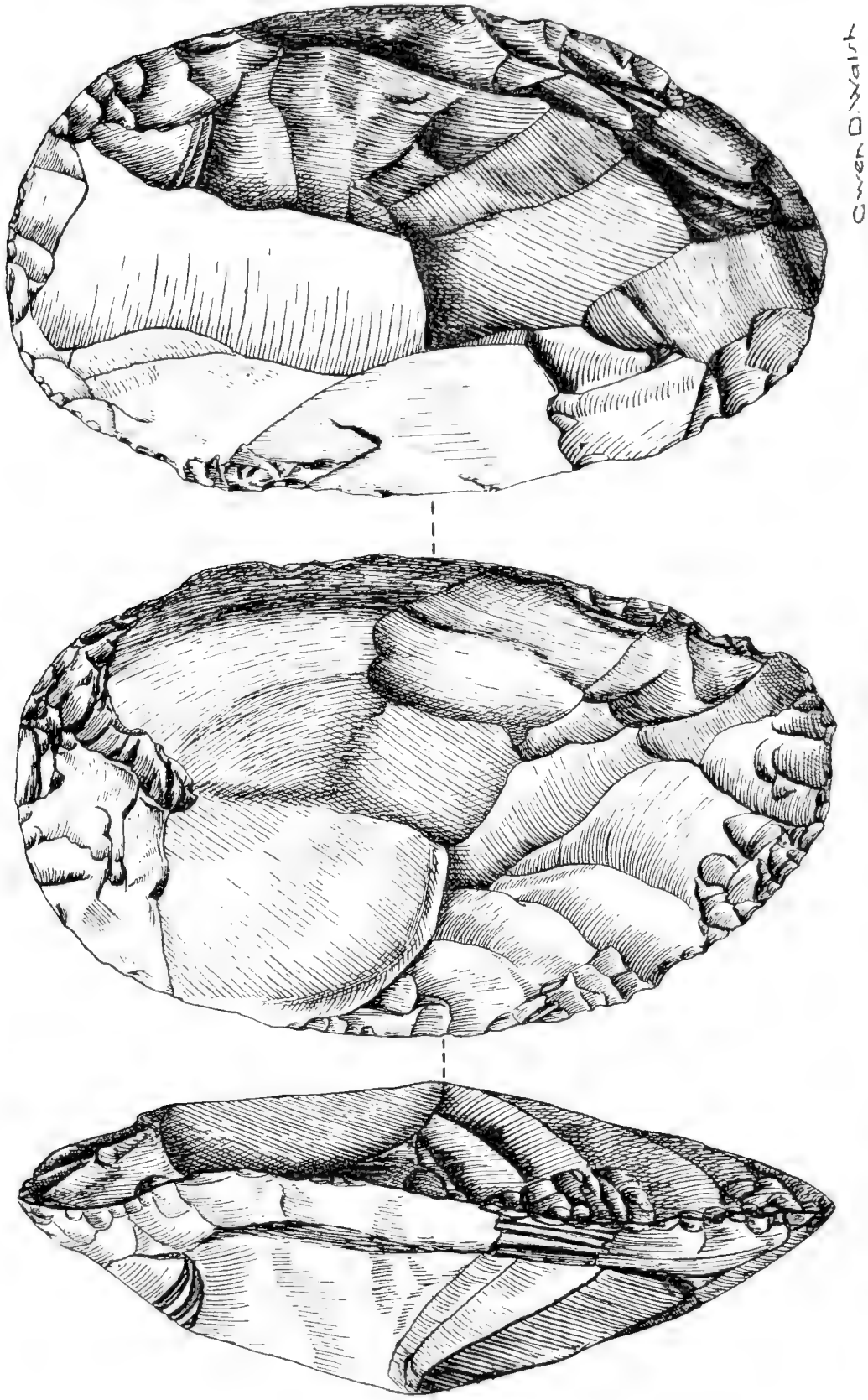

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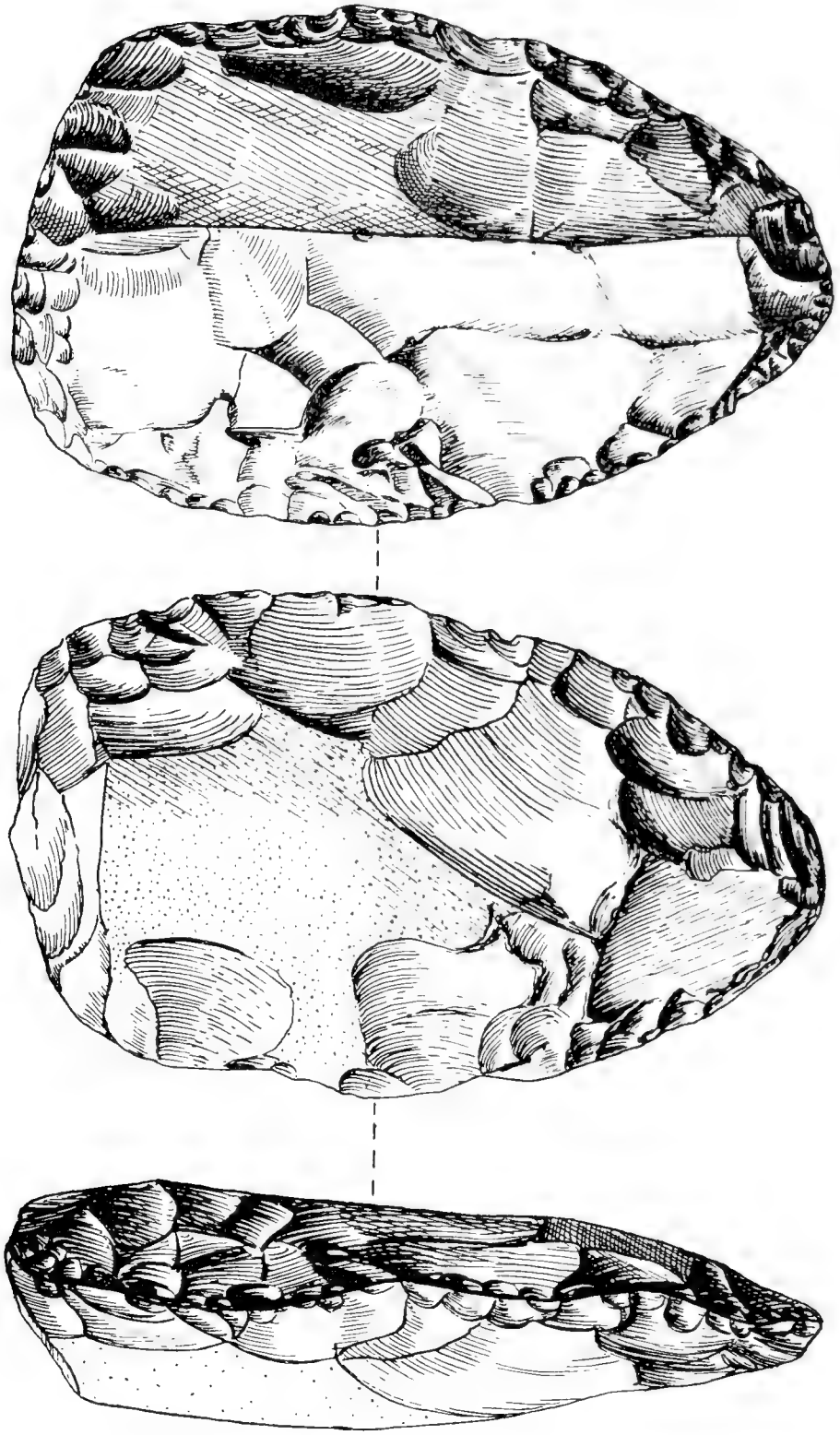

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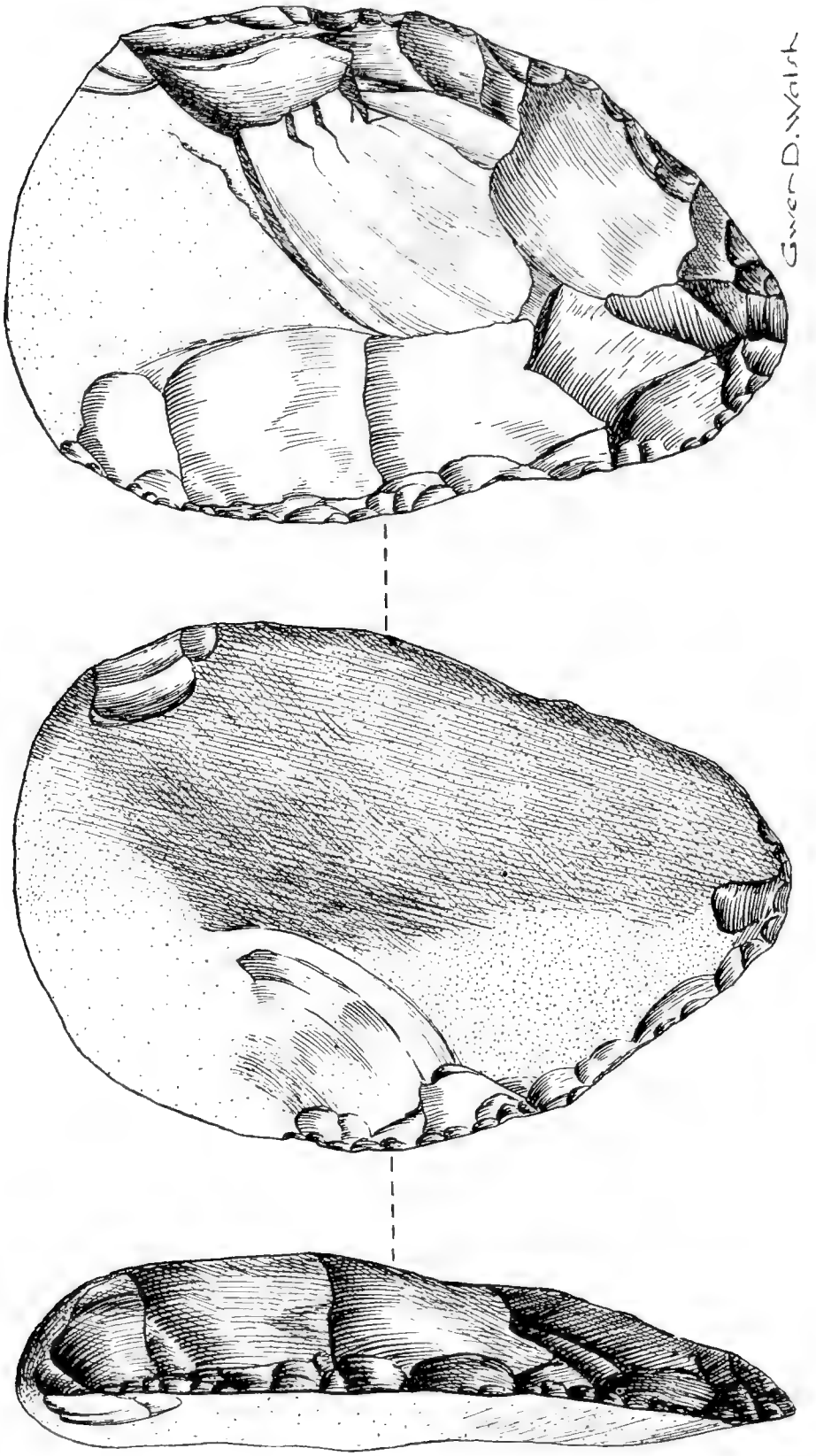

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ALLEGED METEORITE FROM HORSHAM, VICTORIA.

By George Baker, D.Sc.

Abstract.

A specimen of natural slag collected at Horsham in Victoria, Australia, in 1924, was regarded at the time of its discovery as a meteorite. The nature of this material has now been established and in view of observed meteor phenomena shortly before the discovery of the specimen, it appears that the natural slag resulted from the incineration of vegetable matter and subsequent fusion of its ash with a little admixed mineral matter, under the influence of the heat produced by a burning meteor.

Introduction.

The natural slag from Horsham, was found by a youth on October 15th, 1924, in an area approximately 1 mile west of the township of Horsham in Western Victoria, a day or so after several people in the vicinity had witnessed phenomena attributed to the fall of a meteor. The specimen, alleged to be of meteoritic origin, was received by Mr. W. Reed of St. John's Vicarage, Horsham, who promptly submitted it to the Government Astronomer (Dr. J. M. Baldwin) at the Melbourne Observatory. The specimen was thence despatched for examination and comment to Professor E. W. Skeats at the Melbourne University Geological Department on October 24th, 1924. The author received the specimen in 1950 from Professor E. S. Hills, Geology Department, University of Melbourne, for further examination.

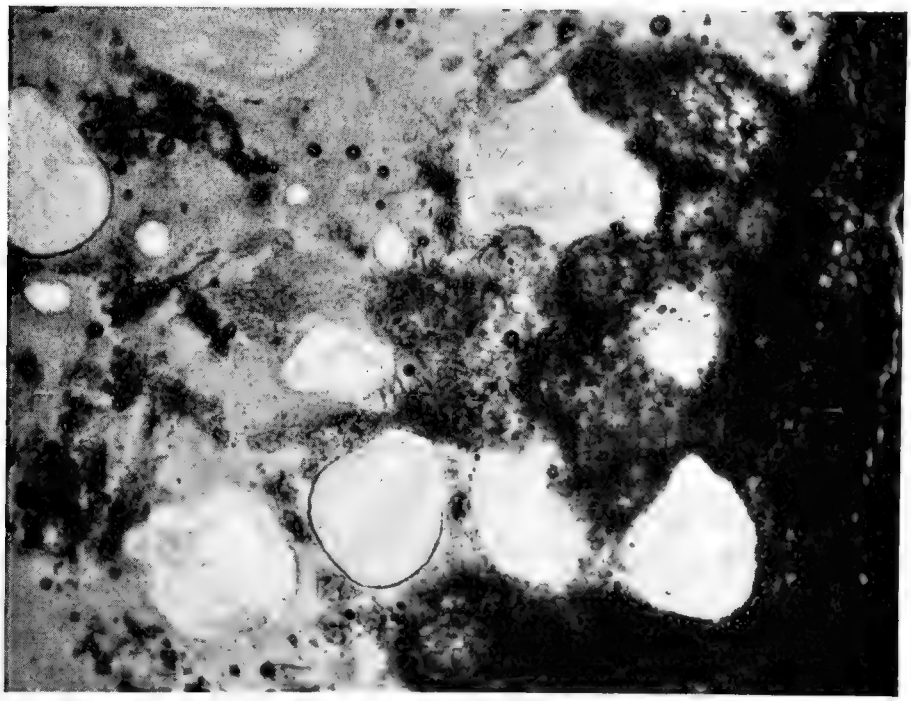
The specimen weighed 92·05 grams as received, and this represents a little over one-half of the complete specimen, which was broken in 1924 before being despatched to the Government Astronomer. The location of the broken-off portion is unknown.

Description of Specimen.

Reconstruction of the shape of the Horsham natural slag specimen from the fragment submitted for investigation, reveals that the original configuration was that of a crudely oval, saucer-shaped object (see photograph 1) measuring approximately 4 ins. by 3 ins. across and $\frac{3}{4}$ to 1 in. in thickness, the centre being $\frac{3}{4}$ in. below the equatorial rim. The concave surface, which was presumably the upper surface, is vitreous and inclined to be ropy, but the convex, presumably under surface, is more sintery in appearance, except in equatorial regions where for $\frac{1}{2}$ in. below the rim, much of the surface is vitreous like the concave surface.

Freshly fractured surfaces of the specimen, broken across radially, reveal the marked vesicular character of its interior. Approximately 25 per cent. of the gas cavities present are lined with a thin crust of a soft, white, chalky substance that is isotropic to cryptocrystalline and is regarded as a residuum from wood ash and fluxes. Remnants of carbonized plant tissue are loosely attached to the walls of some of the larger, elongated cavities.

1. Side view of the Horsham natural slag specimen, showing saucer-shape and vesicular character of the interior. (Natural size.)



2. Thin section of glass showing included plant tissue on right, large and small bubbles in centre and on left. (× 100.)

The glass, which is principally pale bottle green in colour, becomes black in the vicinity of cavities containing partially incinerated plant fibres. Impressions of plant tissue have been preserved as casts in parts of the glass, but wherever still present, the plant tissue has been largely converted to charcoal.

Fragments of the glass immersed in refractive index liquids show smoke-coloured streaks composed of aggregates of minute, rounded, dark brown to black particles representing partially dispersed remnants of carbonized plant tissue. Minute cavities associated with such areas are bubble-like and evidently partly due to gases discharged from the heated plant tissue and eventually trapped in the glass on rapid cooling. Some cavities, however, represent isolated remnants of plant cell structures. The refractive index of the glass varies from 1·530 (colourless) to 1·535 (pale yellowish-green).

Microscope sections (photograph 2) reveal that thin plates of the glass have few flow lines, locally restricted to regions around gas cavities. Rare, partially fused quartz grains are subangular to rounded and contain very rare needles of apatite. These inclusions of apatite, however, are insufficient to account for the P_2O_5 content (see table 1), the bulk of which must lie occult in the glass. Ninety-five per cent. of the Horsham slag consists of vesicular glass, the remainder being mainly plant remnants (charcoal, &c.) and a little quartz. The larger of the gas pores range up to 6·0 by 3·0 mm. across; smaller gas pores are numerous and range from 0·04 mm. to 0·01 mm. (photograph 2).

A polished surface of the glass shows scarce, minute specks of pyrite, none of which exceeds 0·001 mm. in size.

The remnants of plant material in the glass show various phases of destruction and dispersal. In addition to the larger carbonized fragments visible in the hand specimen, there occur in thin section:—

(i) fibrous tissues that are birefringent, but with the cell contents carbonized;

(ii) ghost-like remnants of plant tissue, the cell structures of which are composed of masses of fine, short fibres showing birefringence and straight extinction. These fibres resemble some of the constituents of the white material lining the walls of certain cavities and evidently have their origin in the salts contained in plant tissues;

(iii) occasional isolated three dimensional rosettes and cruciform crystals that are weakly anisotropic and allied to the fibres in the remnant plant-cell structures;

(iv) colourless, isotropic bodies that are frequently concentrated in the glass surrounding the altered plant tissues and anisotropic fibres. They are sub-rounded in outline, average 0·20 mm. across and have a slightly higher refractive index than the enclosing glass. These bodies are evidently lechatelierite particles derived from the silica content of the altered plant tissues, or alternatively have resulted from the fusion of small quartz grains caught up in the original aggregate of vegetable matter. Clusters of small, weakly anisotropic particles attached to some carbonized wood fragments are incompletely fused, siliceous soil particles originally adhering to the vegetable matter;

(v) rare pollen grains and small, reddish-brown resin bodies.

Chemical Analysis.

A chemical analysis of the Horsham natural slag has been carried out in the chemical laboratory of the Mineragraphic Investigations Section, Commonwealth Scientific and Industrial Research Organization, with the following results (Table 1):—

TABLE 1.

	%
SiO_2	60·04
Al_2O_3	1·75
Fe_2O_3	0·18
FeO	0·13
MgO	3·90
CaO	9·28
Na_2O	10·63
K_2O	11·53
H_2O (+)	1·06
H_2O (−)	0·18
CO_2	0·32
TiO_2	tr.
P_2O_5	0·73
MnO	0·47
C	0·08
Cl_2	0·03
SO_3	0·02
Total	100·33

Neither nickel nor chromium was detected in the chemical analysis (Analyst: G. C. Carlos).

The low alumina and high potash and soda contents of the Horsham slag, together with the presence of carbon and significant quantities of MnO, are indications of vegetable source materials. The lime content is comparable with the amounts of lime contained in glasses and slags derived from vegetable matter, as in such products as straw silica glass from O.B. Flat, South Australia, where the lime content is 8·56 per cent. (Fenner, 1940), and slag from charcoal in the suction gas plant, Stawell, Victoria (Baker and Gaskin, 1946, p. 94), where the lime content is 8·21 per cent. The lime content in other natural glasses such as impactites, Darwin Glass, Libyan Glass, australites, &c., is much lower, ranging from nil to 5·25 per cent. (Baker and Gaskin, 1946, p. 94).

Comparison with Other Fused Products of Natural Origin.

The alleged meteorite from Horsham is referred to herein as a natural slag, because it is a completely fused product, formed in the presence of fluxes and hence bears little relationship or resemblance to natural sinter (*cf.* Baker, 1953a) which is a partially fused, clinker-like product devoid of fluxing materials. Such clinker-like masses are usually fused soils of siliceous character, relatively free of vegetable matter, that have evidently been fused by lightning phenomena. The Horsham slag not only differs from such sinters, but also bears no relationships to fulgurites, which are well-known products of lightning fusion. Moreover, the slag is both mineralogically and chemically unlike the clinkers derived from the natural incineration of coal seams, e.g. the naturally fused sub-bituminous coal ash of Leigh Creek, South Australia (Baker, 1953b). Neither is it allied to impactites (due to " meteorite splash "), nor to tektites (extra-terrestrial), and is certainly not of volcanic or of artificial origin. The general appearance of the Horsham specimen, taken in conjunction with its chemical composition, its low specific gravity (2·00—determined in the powdered form at 20° C) and the fact that it commenced to fuse in the laboratory at approximately 650° C, places this natural slag in the same category as a group of products referred to variously as " straw silica glass ", " slag from charcoal ", &c.

Origin of the Natural Slag.

The source materials of the Horsham natural slag consisted of the ash residue from incinerated plant materials containing a little admixed mineral matter. The source of heat is not definitely

known, and can only be inferred by the elimination of certain heating agents and by taking cognizance of certain observed phenomena recorded in Mr. W. Reed's letter to the Government Astronomer in October, 1924.

Fusion was evidently rapid and due to a source of heat of short duration, followed by rapid cooling. Heating by lightning, bush fires, grass fires, haystack fire, and the like, is ruled out by the fact that no phenomena indicating any of these agencies were recorded at the time of discovery of the specimen. On the other hand, Mr. W. Reed's letter of 21st October, 1924, sets out evidence for the belief that meteoritic phenomena had occurred near Horsham shortly before the specimen was found. The letter states that on October 13th, 1924, " a brilliant meteor fell about a mile to the west of this town (Horsham) and was seen from close (at hand) by at least one man. The flash of light was very brilliant and the detonation like the report of a cannon. The detonation was heard by many people at eight o'clock or a little later. Apparently the object burst before it touched ground, for no trace of its having disturbed the soil can be found. It is a fallow paddock over which it is supposed to have burst. The fragment I am sending you was found a day or so after by a lad living in the vicinity. I have compared it with all products of coal from gas works and elsewhere, but this fragment seems to be *sine generis* ".

The fact that the specimen is particularly fresh in appearance points to its obviously recent age. Its chemical composition shows that it is essentially similar to the " straw silica glass " formed as residue from burning haystacks, where the silica contained in grass fuses with the alkalies, &c., to form a slag-like product. This in itself, however, does not necessarily imply a similar source of heat for the production of the Horsham natural slag, and if the observed phenomena have been correctly interpreted and no grass fire, whether accidentally or purposely generated, had occurred, then it becomes highly probable that an incandescent meteorite, bursting over a fallow paddock and almost burnt-out on landing, could have supplied the heat necessary to incinerate aggregated vegetation and fuse the residual ash and attached soil particles to form a glassy slag. No true meteorite was located and no estimates were given of the height at which the phenomena were observed. No further specimens are known to have been found in the area where the observations were originally made.

Acknowledgments.

The author is indebted to Professor E. S. Hills of the University of Melbourne, for making available the Horsham alleged meteorite and the accompanying explanatory letter from Mr. W. Reed. Thanks are due also to J. McAndrew, Ph.D., for the photograph of the specimen, and to E. Matthaei, Dip.Opt., for the photograph of the thin section.

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NOTES ON THE HOST RELATION OF SOME AUSTRALIAN ICHNEUMONIDAE, WITH A DESCRIPTION OF A NEW SPECIES.

By Arthur W. Parrott, New Zealand.

Through the kindness of Mr. F. Erasmus Wilson, Melbourne, a small but interesting collection of bred Ichneumonidae was received, and the result of an examination of this material has revealed a new species of *Campoplegid* and unrecorded hosts of several previously described species.

Family ICHNEUMONIDAE.

Subfamily OPHIONINAE.

Tribe CAMPOPLEGINI.

CAMPOPLEGIDEA WILSONI sp. nov.

Male. Length of head and thorax, 4 mm.; abdomen, 8·5 mm.; forewing, 8·5 mm.; and antennae, 10 mm.

Colour. Head, thorax, antennae, mandibles, tegulae, propodeum and all coxae entirely black; all trochanters brown, anterior and intermediate lightly infuscated; anterior legs yellowish brown, four basal joints of tarsus, lighter, almost yellow; intermediate legs with femora and apical tarsal joint brownish, the remaining joints yellowish; posterior legs entirely brown; abdomen brown, second tergite dorsally black, except apex, sixth and following segments laterally infuscated, with the parameres deeply infuscated; wings hyaline, irridescent, extreme base of costa yellow, costa blackish, stigma brown, except margins which are considerably darker, veins very dark brown.

Structure. Face and clypeus closely and distinctly punctured, finely rugosely so in places; malar space almost obsolete; mandibles wide, their width at base equals nearly three-quarters of their length, the upper tooth slightly longer than lower; front and vertex shagreen; ocelli moderately large; ocellocular space about half the disatnce between the posterior ocelli; occipit posteriorly subvertical; face and clypeus clothed with long silvery pubescence with shorter silvery pubescence on temples; antennae 56 segmented; prothorax shining and diagonally finely striated; mesopleurae, anteriorly and on lower half evenly but not closely punctured; subalar tubercle well developed, punctate-rugulose; from the subalar tubercle extending diagonally to a fovea situated close to the epimeron sulcus a little below the middle, is a depression transversely striated, with a small shining impunctate area immediately above the fovea adjacent to the epimeron sulcus; the epimeron sulcus strongly transversely carinate throughout its length; metapleurae very closely and rugosely punctate; posterior coxae sparsely and finely punctate; mesonotum very closely and finely punctate; notauli obsolete; tegulae with very minute and shallow punctures; scutellum broadly rounded posteriorly, convex with the posterior slope subequal to anterior slope, the whole finely and rugosely punctate with the lateral carinae present only along basal quarter; propodeum, gradually narrowing from base to apex with a well

defined longitudinal sulcus from base to apex, the segment not areolated, all carinae obsolete; spiracles linear about three and a half times as long as broad; the sides of the propodeum are vertical and the carina separating the propodeum from the metapleurae weak, the whole segment is finely transversely striolate: posterior femora sparsely and finely punctate; a little shorter in length than the tibiae; tibiae sparsely and weakly spined; posterior metatarsus as long as the three following joints combined, the apical joint only slightly longer than fourth; posterior tarsi claws small strongly bent at apical two to three from base and with distinct pectinations on basal half; abdomen with petiole slightly swollen in apical third; spiracles not prominent laterally, and separated from each other by a distance a little over one-third the distance from a spiracle to posterior border of the tergite; second tergite somewhat shorter than the first tergite, with the spiracles situated a little beyond the middle of the lateral border; gastercoeli well impressed and situated about the middle of the tergite along the lateral border; remaining tergites strongly compressed.

Wing venation. Nervulus strongly postfurcal; second abscissa of discoideus shorter than the third abscissa; the outer lower angle of the second discoidal cell slightly obtuse; areolet strongly petiolate, the length of the petiole about equals the height of the areolet which is large; second intercubitus slightly curved the recurrent vein straight; hindwing with six hamuli evenly spaced, all veins apically pellucid, indicated by folds in the wing; there is a stump of a vein at junction of abscissula and intercubitella; nervellus vertical very faintly angled well below its centre; discoidella entirely absent, indicated by a fold in the wing—

One male, holotype, Cumberland Falls, Victoria, Australia, 2nd January, 1954 (F. E. Wilson).

One male? (abdomen missing) paratype, Cumberland Falls, Victoria, Australia, 2nd January, 1954 (F. E. Wilson).

The holotype deposited in the National Museum, Melbourne, paratype in collection of Mr. F. E. Wilson.

This species is closely related to *Campoplex negatus* Turner (1919, p. 556), but differs in the more coarsely punctate face and mesonotum, the relatively longer antennae, which are definitely longer than the abdomen, the less well-marked notauli and the external areas on the propodeum not defined, the areolet strongly petiolate, the relatively shorter first tergite of the abdomen compared with the length of the second tergite and in the black mandibles, tegulae and anterior coxae which in *C. negatus* are yellow.

This species is named in honour of Mr. F. Erasmus Wilson, whose interest in Australian entomology is well-known and whose wide knowledge on Australian insects has been of the greatest assistance to the author.

NOTHANOMALON MERIDIONALIS Turner.

Turner (1919) originally described this species from Tasmania. It has not previously been recorded from the mainland, although it appears to be a fairly common species in Victoria, and South Australia. In the present specimens the face and clypeus appear to be more strongly punctured than is the case in the typical form, otherwise they agree well with Turner's excellent description.

One male and one female, Glen Wills, Victoria, 1951; ex pupae *Oreisplanus munionga* Olliff. (F. E. Wilson).

One male, Heywood, Victoria, Australia, 25th December, 1947; ex *Hesperilla chrysotricha cyclospila* Meyr and Lower (F. E. Wilson).

One female, Broadford, Victoria, Australia, 5th December, 1953; ex *Hesperilla donnysa patmos* Wath. (F. E. Wilson).

One male, Toora, Victoria, Australia, 20th January, 1954; ex pupae *Hesperilla donnysa patmos* Wath. (F. E. Wilson).

Hosts. The hosts recorded above for *N. meridionalis* Turner are *Oreisplanus munionga* Olliff., *Hesperilla chrysotricha cyclospila* Meyr and Lower, and *H. donnysa patmos* Wath.

Subfamily CRYPTINAE.

POECILOCRYPTUS NIGROMACULATUS Cameron.

This species is mentioned here to record two females captured on Mt. Buangor Range, Victoria, on 16th January, 1954, by Mr. Wilson.

Subfamily ICHNEUMONINAE.

Tribe ICHNEUMONINI.

ICHNEUMON PROMISSORIUS Erichson.

Ichneumon promissorius Erichson, Arch. f. Naturg., vol. 8, p. 254, 1842.

Excephanes leucaniae Tryon, Queensland Journ. Agric., vol. 6, p. 35, 1900.

Probolus albocincta Cameron, Entomologist, vol. 39, p. 181, 1906.

Probolus varilineatus Cameron, Proc. Linn. Soc. N.S.W., vol. 37, p. 174, 1912.

Ichneumon (*Euichneumon*) *promissorius* Turner, Trans. Entom. Soc. London, for 1918, p. 344, 1918.

Ichneumon albocinctus Heinrich, Ann. Mag. Nat. Hist., ser. 10, vol. 20, p. 259, 1937.

Ichneumon promissorius Parrott, New Zealand Entomologist, vol. 1, no. 3, p. 16, 1953.

The nomenclature of this common Australian and New Zealand species has been discussed in a previous paper (Parrott, 1953, p. 16). The hosts of *I. promissorius* are usually Noctuid larvae, and it has been reared from a number of different species in Australia and New Zealand. Because of the wide distribution and abundance of this species throughout Australia, it must be considered a valuable agent in the natural control of army-worms and cut-worms.

One female, S.E. South Australia, 28th November, 1952, ex mass of pupae of *Sideridis ewingii* (*Wwd.) (N. B. Tindale).

Subfamily PIMPLINAE.

Tribe PIMPLINI.

ECHTHROMORPHA INTRICATORIA (Fabr.).

This conspicuous and common species is found throughout the greater part of Australia and New Zealand. The hosts of *E. intricatoria* in New Zealand have previously been recorded (Parrott, 1952). The following specimens have been bred by Mr. F. E. Wilson from Australian hosts.

One male, Bunbury, Western Australia, 9th November, 1945; bred from pupae of *Hesperilla chrysotricha chrysotricha* Meyr and Lower (F. E. Wilson).

**Sideridis ewingi* Wwd. is a well-known pest in Australia and New Zealand and for many years been placed in the genus *Persectania*.

One male, Mt. Wellington, Tasmania, 3rd February, 1949; ex pupae of *Hesperilla donnysa aurantia* Waterhouse (F. E. Wilson).

One male, Buronga, New South Wales, 17th August, 1950; ex pupae of *Ogyris olane ocela* Waterhouse (F. E. Wilson).

One male, Mt. Compass, South Australia; ex *Hesperilla chrysotricha cyclospila* Waterhouse (F. E. Wilson).

One female, Prince of Wales Bay, Tasmania; ex pupae *Hesperilla chrysotricha plebeia* Waterhouse (F. E. Wilson).

ACKNOWLEDGMENTS.

To Mr. F. Erasmus Wilson, of Melbourne, the author wishes to express his thanks for the opportunity of examining the material on which this paper is based.

The present paper is part of a general work on the systematics of Australian Ichneumonidae and Braconidae for which financial assistance has been given by the Committee of the Science and Industry Endownment Fund, Melbourne, and for which the author wishes to express his grateful thanks. Also to the National Museum, Melbourne, a grant to help finance this work is gratefully acknowledged.

ADDITIONAL REFERENCES.

Parrott, A. W. (1952), " New Zealand Ichneumonidae—II. The Tribe Echthromorphini (Pimplinae)." Trans. Roy. Soc. New Zealand, vol. 80, part 2, pp. 155-170.

Turner, R. A. (1919), " Notes on the Ichneumonidae in the British Museum—I." Ann. Mag. nat. Hist. (9) vol. 111, pp. 550-558.

A REVIEW OF THE GENUS BACHOREMA Mosely, FAM. RHYACOPHILIDAE, TRICHOPTERA.

By Arturs Neboiss, M.Sc., F.R.E.S., Assistant Curator of Insects, National Museum of Victoria.

Summary.

In this paper, descriptions are given for the first time of females of *Bachorema gisba* Mosely and *B. obliqua* Mosely, and the male genitalia of *B. gisba*. New localities are recorded for both species, and *B. obliqua* is new to Victoria. A key is given for separating the genus *Bachorema* from other genera within the subfamily *Hydrobiosinae*.

Introduction.

Two rhyacophilid pupae were collected during June, 1953, in a small creek about 3 miles south of Clunes, Victoria. From these, early in July, one male and one female emerged. The male was identified as *Bachorema gisba* Mos., but a closed discoidal cell was observed instead of an open one, as in the description given by Mosely. The female specimen was very similar in colouration, slightly larger, and was believed to be the same species. Early in September the locality was visited again, and a number of rhyacophilid pupae collected which were at the point of hatching. During the next two weeks, fifteen specimens of this species emerged and were available for study. Other collecting trips in central Victoria gave further rhyacophilid material, and *B. gisba* pupae were collected in the Moorabool River, Eastern Branch, near Ballan, and 4 miles west of Melton in Djerriwarrh Creek. Amongst the other Rhyacophilidae material were five specimens of *Bachorema obliqua* Mos. This species was described by Mosely from one male specimen from Queensland.

Arising from the above collecting, it is now possible to describe *B. gisba* and *B. obliqua* females, *B. gisba* male genitalia, and add some information to the generic characters, together with changes to the key to the subfamily *Hydrobiosinae*.

Genus BACHOREMA Mosely.

Male genitalia in both species somewhat similar. Inferior appendages two jointed, with long spines arising from the inner surface. Lateral filaments of the fifth segment present.

Short process to the seventh or sixth and seventh sternites. Wing neuration in the female differs from male.

Female anterior wings with closed discoidal cell, apical forks nos. 1, 2, 3, 4, and 5 present, and all stalked. The posterior wings are similar to those of males.

Bachorema obliqua Mos. (figs. 1, 5, and 8).
1953, Mosely and Kimmins. Trich of Austr. and N. Z., p.494.

This species is recorded from Queensland National Park and described from one male only. There are now two males and three females available from Victoria, and a description of the female is given in this paper.

The male specimens from Victoria correspond with the original description. It will be added that in the resting position it has a typical dark appearance with an ochraceous line on the back which is wider in the middle portion as shown in fig. 1. The anterior wings in set specimens show light colouring on the posterior margin. The male specimen from Greendale has the third apical fork in the anterior wings with a very short footstalk. The genitalia of both specimens do not show any differences from the original description.

Females generally larger than males with about the same colouring. Anterior wing neuration differs from male in absence of the pouch. Dicoidal cell closed, forks nos. 1, 2, 3, 4, and 5 present, fork no. 2 sessile. Posterior wing similar to that of male.

Genitalia. Abdomen terminates in a blunt apex. A pair of short curved processes arising from the margin of the dorsal plate. The KOH preparation shows a pair of small sacs produced inwards between eighth and ninth tergites. Dorsal part of ninth tergite with the upper part somewhat flattened. Sixth and seventh sternites with short processes, that of sixth slightly larger, raised from a ridge on the sternite and bearing few stout hairs.

Length of the anterior wing—male 7 mm., female 8-9 mm.

One male Greendale 28th October, 1953 (pupae) em. 20th November, 1953.

One male and two females Kinglake West-King Parrot Creek 18th October, 1953 (pupae) em. 21st October resp. 3rd November, 1953. One female Kinglake West-King Parrot Creek 18th October, 1953.

Allotype female Coll. A. Neboiss.

Bachorema gisba Mos. (figs. 2, 3, 4, 6, 7, and 9.)
1953, Mosely and Kimmins Trich. of Austr. and N. Z., p. 494.

Before finalising this paper, Mr D. E. Kimmins, British Museum (Nat. Hist.), London, was asked for further information regarding the closed discoidal cell in the type specimen of *Bachorema gisba.* Mr. Kimmins examined the type, and found that there is, in some lights, a suggestion of a closed discoidal cell, and also gave some advice regarding corrections to the subfamily key.

Careful examination of the available *B. gisba* male material showed that the crossvein closing the discoidal cell under some light conditions is more clearly visible than in others, and also the definition in some specimens is better than in others, but it was always present.

Male genitalia relatively shorter than that of *B. obliqua.* Dorsal plate narrow with two broad downturned hooks at the apex and a pair of warts at the base. Superior appendages very broad, as long as the dorsal plate. Inferior appendages long and stout with curved second joint and long spines arising from the inner surface. Short process arising from the seventh sternite. Discoidal cell in the anterior wing closed.

Female genitalia: The abdomen terminates in a blunt apex, more or less triangular from the side. A pair of small curved processes arise from the margin at the apex of the dorsal plate. Ventrally there is a sub-ellipsoidal plate. Seventh sternite with short process. Another longer one is raised from a ridge of sixth sternite and bears a few stout hairs. Wing neuration differs from the male in a normally formed discoidal area. Anterior wing with apical forks nos. 1, 2, 3, 4, and 5 present and all with footstalks. Discoidal cell closed. The posterior wing similar to that of the male with fork no. 1 wanting. Forks nos. 2, 3, and 5 with footstalks. (There is one aberrant female from Clunes with fork no. 1 absent in the anterior wing and one male with fork no. 3 absent in the anterior wing.)

Specimens from Clunes and Ballan bred from pupae collected during June-September, 1953 and from Melton, August, 1954 appear to be larger than those from Melton, December, 1953 and the type specimen from Gisborne, collected in February, 1917. In my opinion the early spring specimens are larger in size due to a supply of rich food in the water, but in the sparsely running water during summer, the food and oxygen supply for larvae are

apparently so poor that it was affecting the size of the adult insect. No structural differences in the wing neuration or genitalia were observed.

	Gisborne (Type)	Clunes and Ballan	Melton (Dec., 1953)	Melton (Aug., 1954)
Males	5 mm.	7- 9 mm.	6-7 mm.	9 mm
Females ..	—	9-10 mm.	7-8 mm.	—

Altogether 44 specimens were examined—from these 13 males and 22 females were pinned, and 4 males and 4 females placed in alcohol. One female—allotype Clunes, 7th September, 1953 (pupae) em. 15th September, 1953, 9 females—Clunes, 7th September, 1953 (pupae) em. 8th to 17th September, 1953 (one with fork no. 1 absent in the anterior wings). One female—Clunes, 11th June, 1953 (pupa em. 2nd July, 1953, 10 females—Melton, 31st December, 1953 (pupae) em. 3rd to 6th January, 1954, 1 female—Melton, 31st December, 1953 (ad.), 1 female—Avenel, 24th November, 1953, 1 male—Clunes, 11th June, 1953 (pupa) em. 5th July, 1953 (drawing of male genitalia prepared from this specimen), 5 males Clunes, 7th September, 1953 (pupae) em. 13th to 17th September, 1953, 7 males—Melton, 31st December, 1953 (pupae) em. 4th to 6th January, 1954, 4 males—Melton, 31st December, 1953 (pupae) em. 4th to 10th January, 1954 in alcohol (3 in Coll. W. Döhler), 4 females—Melton, 31st December, 1953 (pupae) em. 4th to 10th January, 1954 in alcohol (3 in Coll. W. Döhler).

Additional material. Three males—Melton, 18th August, 1954 (pupae) em. 18th to 20th August, 1954. (In National Museum of Victoria.)

Allotype in Coll. A. Neboiss.

In the genus *Bachorema* there are two major points separating both species and sexes within one species:—

1. Discoidal cell is open in *B. obliqua* male, but closed in *B. obliqua* female and *B. gisba* both sexes;
2. In the posterior wing apical forks nos. 1, 2, 3, and 5 present in *B. obliqua* (both sexes), but forks nos. 2, 3, and 5 present in *B. gisba* (both sexes).

These points enable the genus to be separated in to three couplets instead of one, and this key will be subject to further revision when more information is available for other species and sexes. The following is the modified key from Mosely and Kimmins (1953), p. 405, omitting couplets not necessary for the indentification of the genus *Bachorema* Mos.

1. Discoidal cell in anterior wing closed. 2
   Discoidal cell in anterior wing open. 10
2. Apical forks no. 1, 2, 3, and 5 present in posterior wing. .. 3
   Apical forks nos. 2, 3, and 5 present in posterior wing. 8
3. Fork no. 2 in anterior wing with footstalk. .. .. .. *Hydrobiosis* McL.
   Fork No. 2 in anterior wing sessile. 4
4. Median cell in anterior wing closed. 5
   Median cell in anterior wing open. 5
5. (As before—see Mosely and Kimmins, p. 405.)
6. Fork no. 1 in posterior wing sessile. .. .. *Anachorema* Mos. (except *Anachorema evansi* Mos.)
   Fork No. 1 in posterior wing with footstalk 7
   (except *Notiobiosis pallescens* Banks).
7. Fork no. 2 in posterior wing sessile .. .. 7a.
   Fork no. 2 in posterior wing with footstalk .. .. *Bachorema obliqua* Mos. females.
7a. In posterior wing of ♂ a narrow, cell-like structure, lined with fine hairs, situated between Cu2 and IA .. .. *Taschorema* Mos.
   No such structure in posterior wing of ♂ .. .. *Notiobiosis* Banks.
8. A secondary fusion of R4 with R5 in the anterior wing enclosing the facetic spot in a small cell .. .. *Synchorema* Till.
   No such secondary fusion of R4 and R5 9
9. Fork no. 1 in anterior wing sessile; neuration similar in both sexes *Hydrochorema* Till.
   Fork no. 1 in anterior wing with footstalk; neuration differing in the sexes 9a
9a. Males .. .. 9b.
   Females .. .. 9c.
9b. Anterior wing with an oblique pouch or fold on media and a fringe of long hairs on stalk of fork no. 1 .. .. *Bachorema gisba* Mos. males
   No oblique pouch or fold and no long hairs on stalk of fork no. 1 *Neurochorema* Till. males
9c. Fork no. 2 in anterior wing with footstalk .. .. *Bachorema gisba* Mos. females.
   Fork no. 2 in anterior wing sessile .. .. *Neurochorema* Till. females.
10. Forks nos. 1, 2, 3, and 5 in posterior wing 11
   Forks nos. 1, 2, 3, and 5 *not* all present in posterior wing .. 12
11. Fifth abdominal segment without lateral filaments (New Zealand) *Costachorema* McF.
   Fifth abdominal segment with lateral filaments (Australia) .. 11a.
11a. Forks nos. 1 and 2 in anterior wing with footstalk .. .. *Bachorema obliqua* Mos. males.
   Forks nos. 1 and 2 in anterior wing sessile .. .. *Austrochorema* Mos.
12. (Stays unchanged—see Mosely and Kimmins, p. 405.)
13. Second line: delete "15" and insert "*Allochorema*".
14. (Stays unchanged—see Mosely and Kimmins, p. 405.)
   Delete couplet 15. (M. and K. p. 406.)

ACKNOWLEDGMENTS.

Grateful acknowledgment is made to Mr. D. E. Kimmins, British Museum (Nat. Hist.), London, for the checking of discoidal cell of *Bachorema gisba* Mos. male type specimen and valuable suggestions to the revision of the subfamily key, and to Mr. A. N. Burns, National Museum of Victoria, who read the early drafts and helped in the preparation of this paper.

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EXPLANATION OF PLATES.

PLATE I.—

Fig. 1. *Bachorema obliqua* Mos. (male).

Fig. 2. *Bachorema gisba* Mos. male genitalia lateral.

Fig. 3. *Bachorema gisba* Mos. male genitalia dorsal.

Fig. 4. *Bachorema gisba* Mos. male genitalia ventral.

PLATE II.—

Fig. 5. *Bachorema obliqua* Mos. female anterior and posterior wings.

Fig. 6. *Bachorema gisba* Mos. male anterior wing discoidal cell area showing cross vein.

Fig. 7. *Bachorema gisba* Mos. female anterior and posterior wings.

PLATE III.—

Fig. 8. *Bachorema obliqua* Mos. female genitalia lateral.

Fig. 9. *Bachorema gisba* Mos. female genitalia lateral.

PLATE I

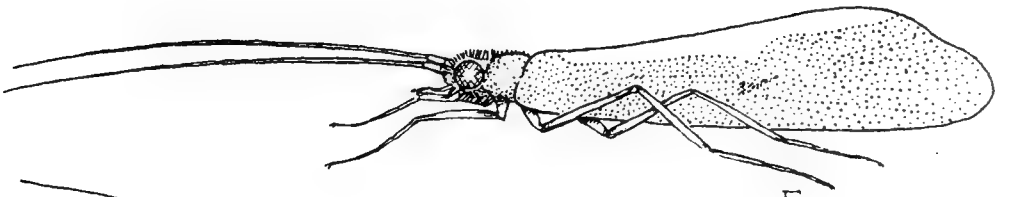


FIG. 1.

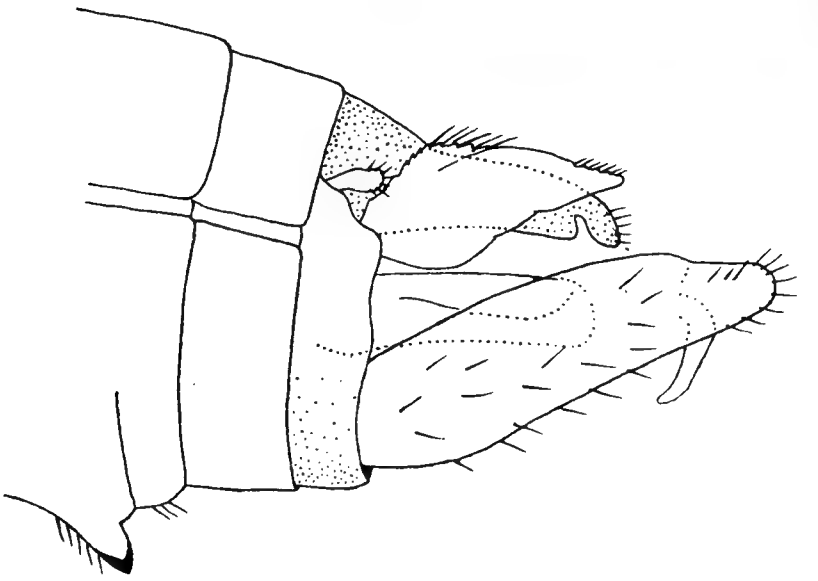


FIG. 2.

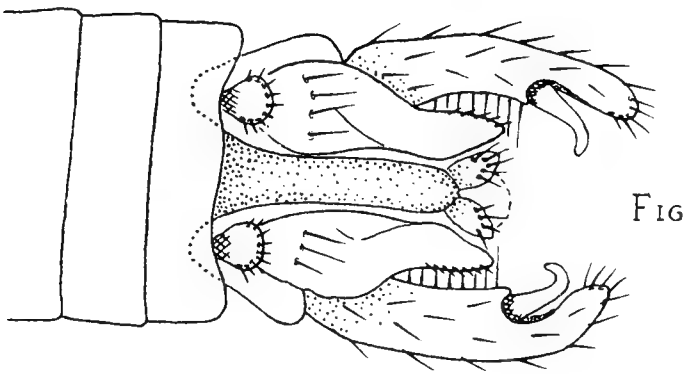


FIG. 3

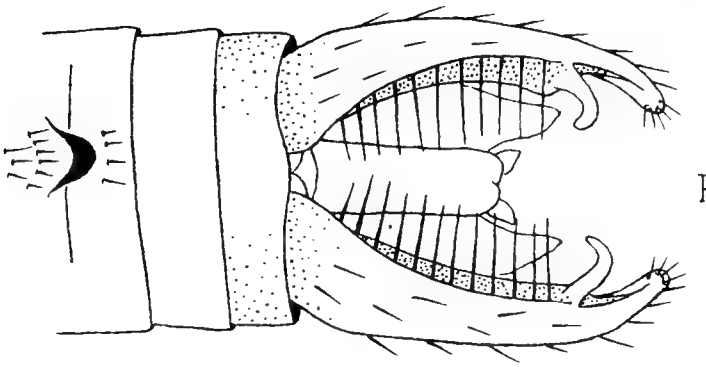


FIG. 4.

A NEBOISS

PLATE II

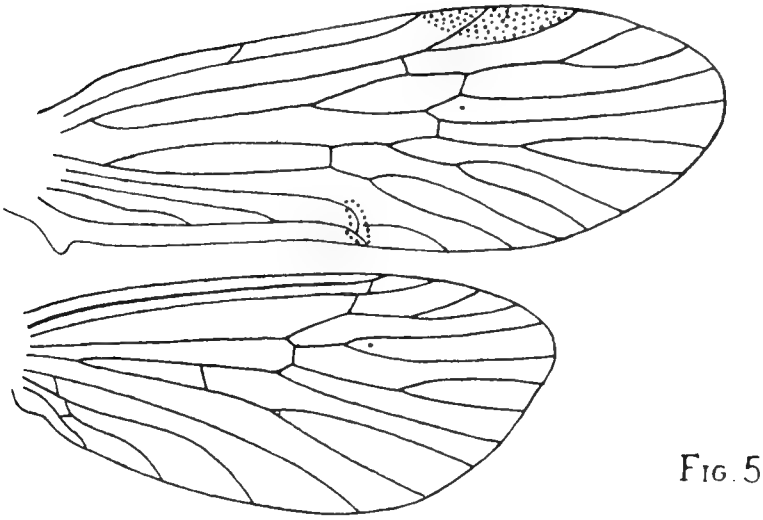


FIG. 5.

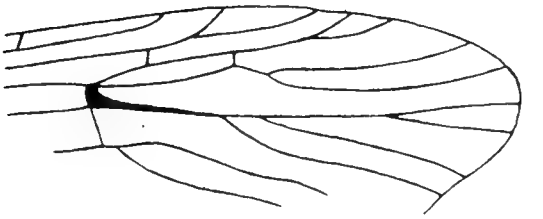


FIG. 6.

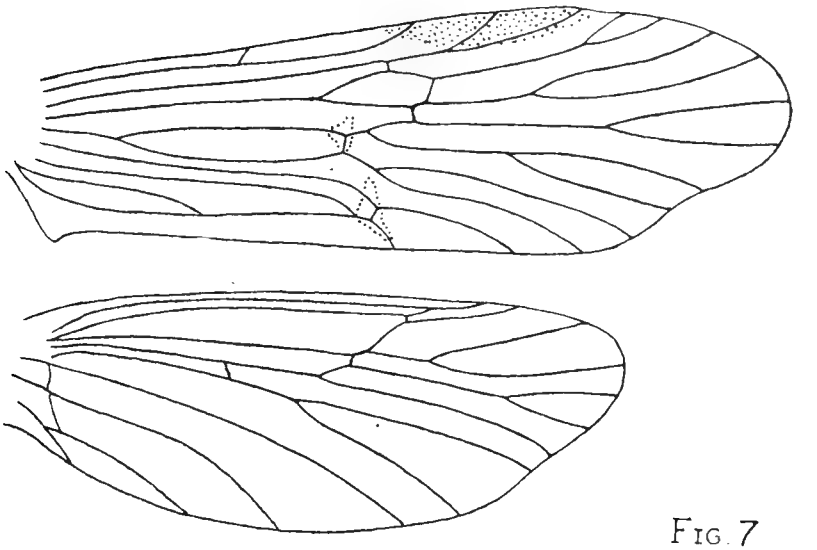


FIG. 7.

A NEBOISS

PLATE. III

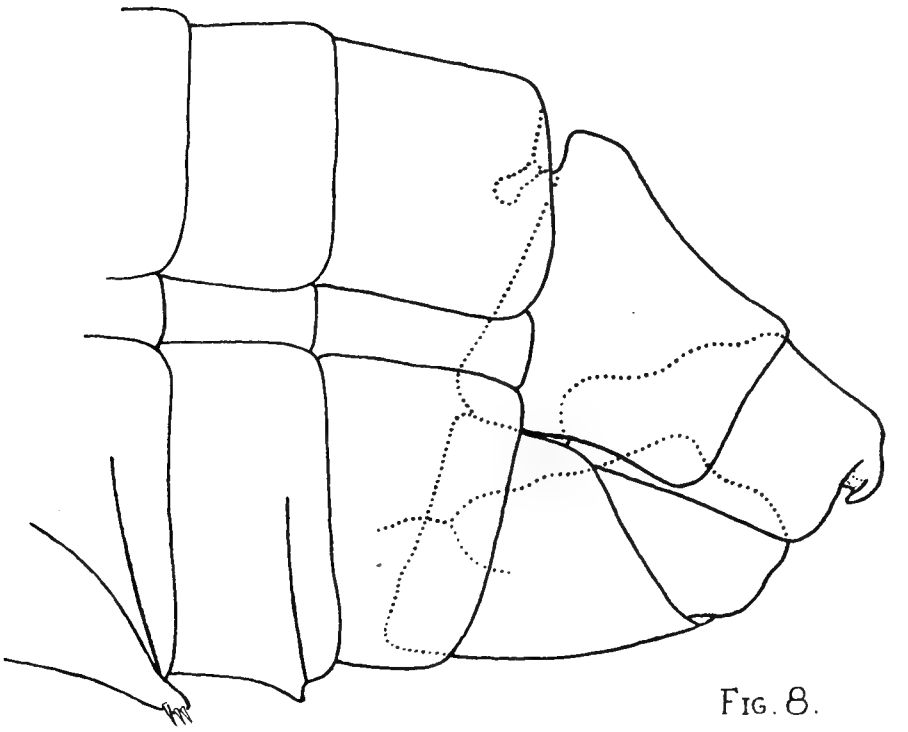


FIG. 8.

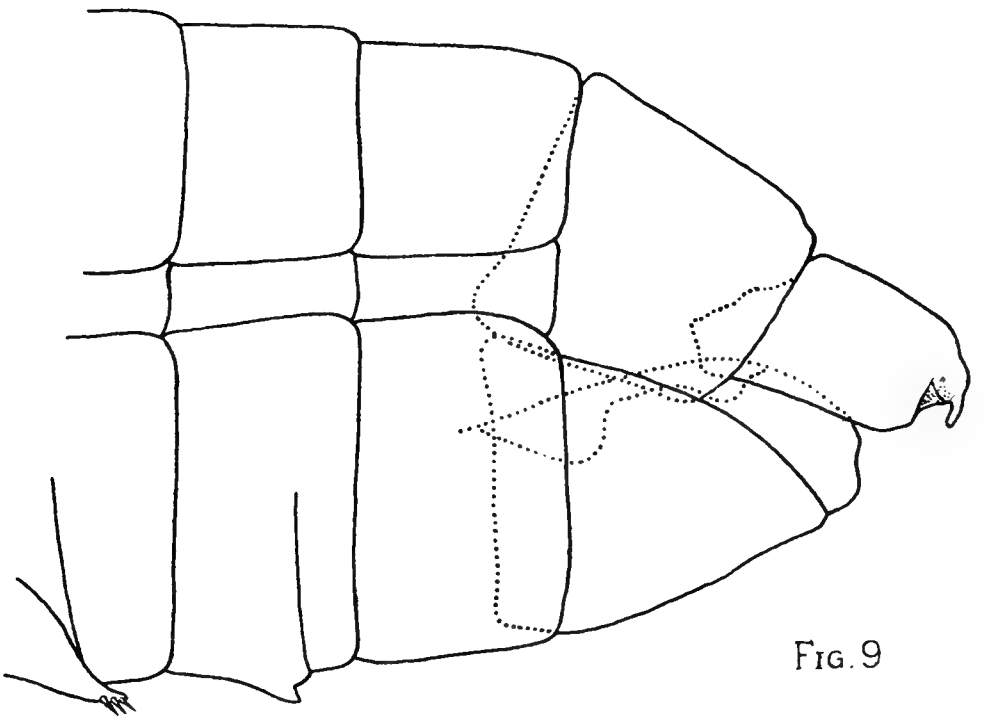


FIG. 9

A. NEBOISS

TWO NEW SPECIES OF PLECOPTERA FROM VICTORIA.

By A. N. Burns, M.Sc., F.R.E.S., Curator of Insects, National Museum and A. Neboiss, M.Sc., FR.E.S., Assistant Curator of Insects, National Museum.

Introduction.

1802. PERLARIAE. Latr. Hist. Nat. 3, 292.

1839. PLECOPTERA. Burm. Handb. Ent. 2, 863.

P. W. Claassen suggests in his " Catalogue of the Plecoptera of the World " in Cornell Univ. Agr. Exp. Sta. Memoir 232, 1940, p. 19, ' It seems advisable to retain the more generally used term *Plecoptera* for this Order.'

Order PLECOPTERA.

Family *Eusthenidae.*

Subfamily *Eustheninae.*

The description of *Thaumatoperla robusta* by the late Dr. R. J. Tillyard, in the Proceedings of the Linnean Society of New South Wales, Vol. 46, 1921, brought to light the existence of a very archaic type of Stone fly, which in fact, could be regarded as a true *Protoperlarian.*

Few specimens only of *T. robusta* exist in collections; the holotype female is in the National Museum collection, Melbourne, together with another female; the allotype male is in the Cawthron Institute collection at Nelson, New Zealand. Both type specimens were collected near Warburton, Victoria, the other female specimen in the National Museum collection being labelled " Millgrove, Victoria; T. H. Tregellas." The description of the allotype male is given (Tillyard) in the Proceedings of the Royal Society of South Australia, vol. 48, 1924.

With this description, Tillyard mentions, " A half-grown larva of this fine species has recently been taken by Mr. F. Erasmus Wilson, in a mountain stream near Mt. Ben Cairn, Millgrove, Victoria; where both male and female specimens of this rare insect have been found by Mr. Wilson and Mr. Charles Barrett. The larva is black, with the thoracic sterna, sutures, and coxae, yellow; the femora tinged with olive-green beneath. A similar larva, full fed, and of great size (about 45 mm. long) was taken by

me on Mt. Kosciusko, New South Wales, in November, 1921. The underside had the yellow colouration replaced by brick red. Thus we may conclude that either *T. robusta* itself, or a related, undescribed species is to be found on Mt. Kosciusko."

It is very likely that this larva just referred to may prove to be the larva of *Thaumatoperla alpina* sp. n., one of the two new species hereunder described:—

Thaumatoperla alpina sp. n.

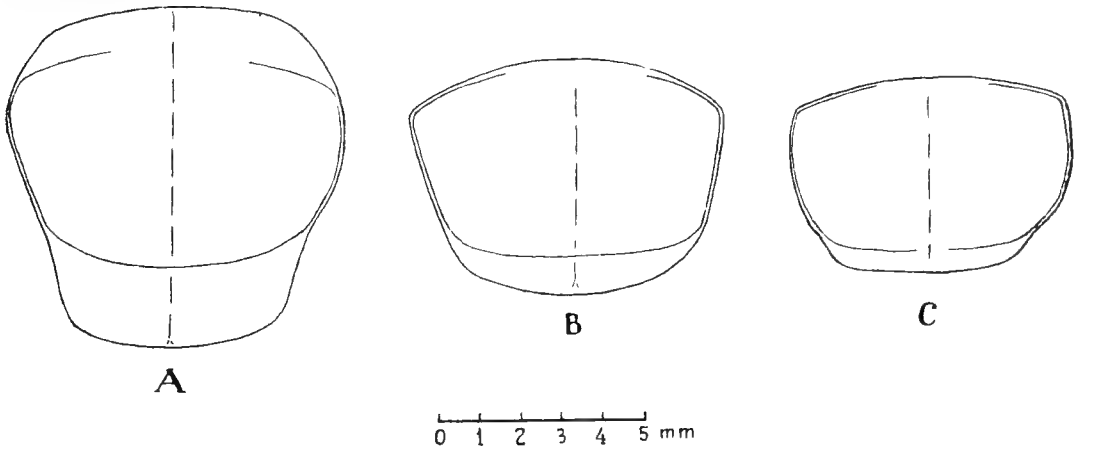
Female, length of body (including head), fresh specimens 36–44 mm.

Anterior wing, length 20–22 mm.; width, 9·5–11·0 mm. Expanse (across). 42–51 mm.

Posterior wing, length, 18–20 mm.; width, 16–18 mm.

Head, black with a greyish spot on each side of the frontal suture just inwards from the base of the antennae.

Eyes, dark olive-grey; *Labrum,* black; *Labium,* brownish-black; *Mandibles* and *Maxillae,* dull-black; *Genae,* dull-black; *Antennae,* black, 54–63 segments, length, 23–26 mm.



A. *Thaumatoperla alpina* sp. n. outline of prothorax.
B. *Thaumatoperla robusta* Till, outline of prothorax.
C. *Thaumatoperlaa flaveola* sp. n., outline of prothorax.

Thorax. Prothorax, length, 8–9 mm.; width, 8–9 mm. Cinnamon rufous (Ridgeway), darkest along anterior ridge which is continued along the sides and just behind the central black marking. A short median ridge connects the posterior margin of the prothorax with the encircling ridge. Central marking black, shiny, almost oval in shape.

Mesothorax, black, with anterior margin yellowish-orange, narrowed at centre.

Metathtorax, black with a fine pale yellowish posterior margin. In the dried specimen the yellowish markings are less intense.

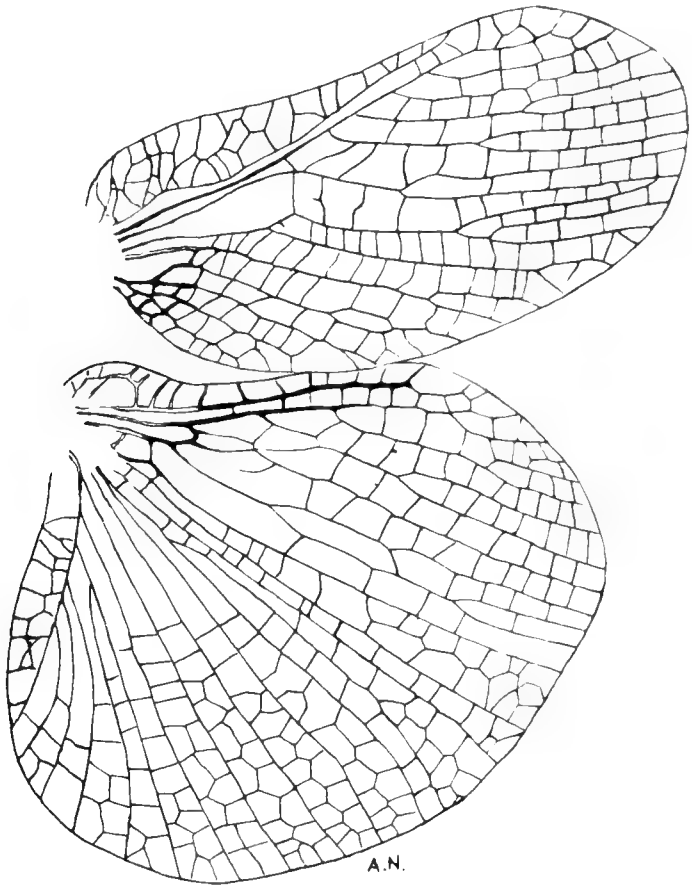
Legs, including tarsi, uniformly black. *Anterior wings,* aniline black, dull, (Ridgeway), *Posterior wings,* black, with dark-blue irridescence.

Abdomen, cylindrical, somewhat flattened dorsally, pale yellowish-grey; ninth and tenth segments recurved forwards; ninth segment black with median dorsal area and posterior margin narrowly yellowish-grey; tenth segment black. *Cerci,* black, with 34–35 segments, length 20–24 mm.

Ventral surface. Prothorax, cinnamon rufous (Ridgeway), between first pair of legs a large black area with a dark-brown longitudinal central band extending from the centre to the hind margin of the black area.

Mesothorax, dull pinkish-yellow with a blackish area between the second pair of legs to about half way to hind margin, and extending round insertions of coxae.

Abdomen, yellowish-grey with dull blackish lateral markings; ninth and tenth segments dull black; ninth segment with a slight median carina on each side of which is a centrally placed tubercle.



Wings: *Thaumatoperla alpina* sp. nov.

The first specimen was brought alive to the National Museum, and was found to be carrying a large mass of eggs which was placed as follows:—The ninth and tenth abdominal segments, including the cerci, were recurved forwards dorsally over the abdomen. The eggs were then actually placed on the ventral surface of the ninth and tenth segments, and held from the top by the cerci. The total number of eggs was found to be 1,029, and each egg measured 1 x ·65 mm. These were carefully placed in water in which they quickly separated out from the mass and settled down individually. After separation, each egg gradually became enclosed within a translucent gelatinous capsule.

Locality, Holotype, Mt. Fainter, Victoria, at between 4,000 and 5,000 feet. April 18th, 1954. Female specimen collected by Mr. J. Brownlie of Elsternwick, Melbourne. This specimen was taken resting on a stump approximately 50 yards distant from the nearest running water.

Paratypes, two females, Mt. Bogong district, Victoria, 4,000 ft. March 16th, 1957, collected by Miss H. Purnel and Mr. A. J. McComb.

Type, HOLOTYPE and PARATYPE females in Coll. National Museum of Victoria.

Thaumatoperla flaveola sp. n.

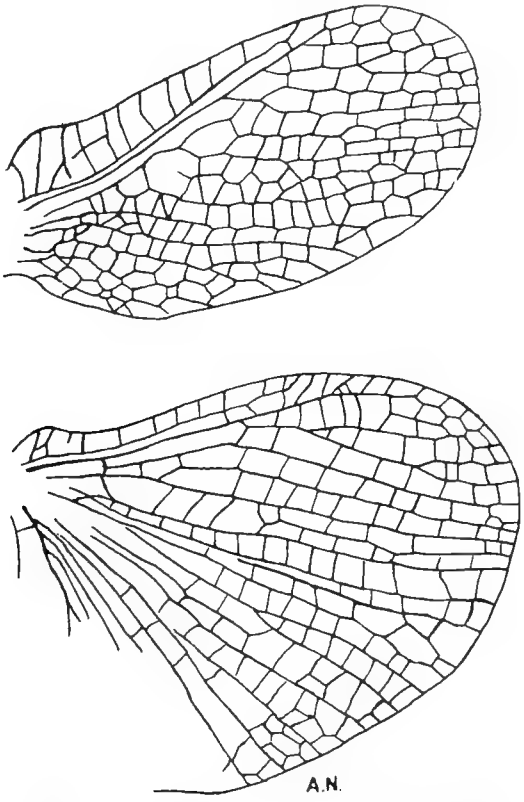
Male, length of body (including head), dried specimen, 23 mm.

Anterior wing, length, 16 mm.; width, 7 mm. Expanse (across) 36 mm.

Posterior wing, length, 16 mm.; width, 13 mm.

Head, reddish-brown with large brownish-black area in front.

Eyes, black; *Labrum,* black; *Labium,* black, lighter towards base; *Mandibles* and *Maxillae,* black; *Genae,* black; *Antennae,* black, 58 segments, length (approx.) 17 mm.



Wings: *Thaumatoperla flaveola* sp. nov.

Thorax. Prothorax, length, 4·5 mm.; width, 6·7 mm. Sudan brown (Ridgeway), shiny, sculptured, prominent encircling ridge, posterior margin black.

Mesothorax, black, shiny, strongly ridged posteriorly. Base of anterior wings dark-brown.

Metathorax, black, anterior portion dark-brown.

Legs, Coxae, dark-brown; *Femora,* dark yellowish brown; *Tibiae,* black; *Tarsi,* black. *Anterior wings,* tawny-olive (Ridgeway) with greyish-brown mottlings in central area and reaching hind margin. *Posterior wings,* deep neutral-grey (Ridgeway), costa and apex tawny-olive (Ridgeway).

Abdomen, cylindrical, flattened dorsally, shining black, ninth segment dark-brown, tenth segment black; these two segments curved upwards. *Cerci,* black, with 28 segments, length (approx.) 15 mm.

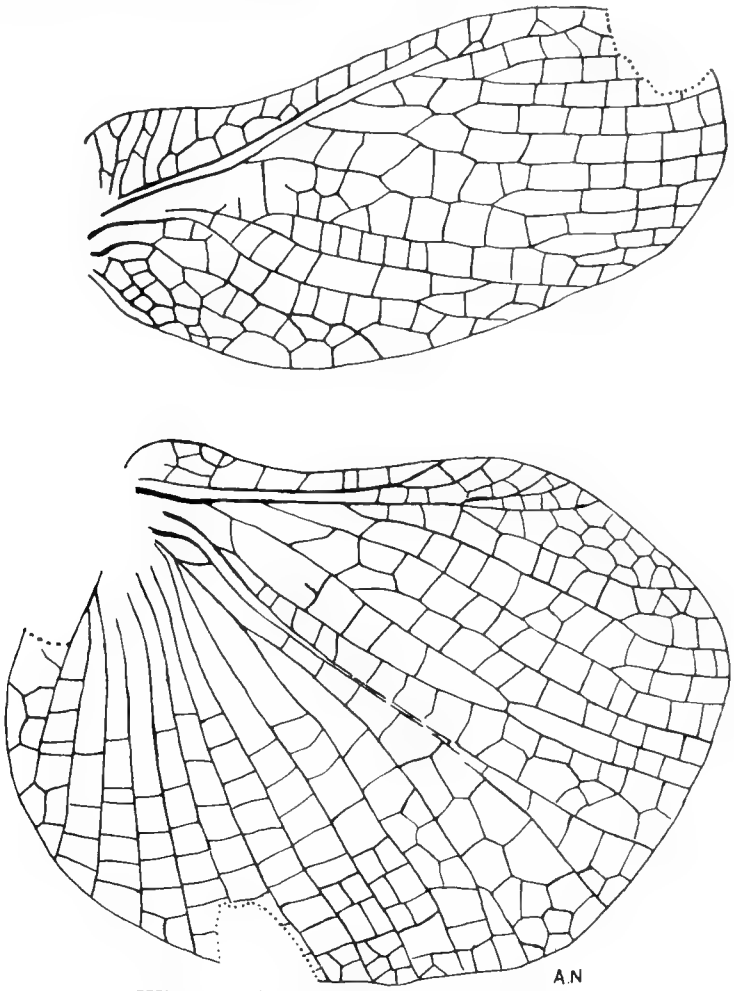
Ventral surface. Prothorax, yellowish-brown, edges of coxal sutures dark-brown.

Mesothorax, dark-brown, edges of coxal sutures almost black.

Metathorax, black, eighth and ninth segments with short brown pubescence.

Locality, this specimen was captured at The Waterfall, Mt. Buller-road, Victoria, on 14th March, 1954, by Mr. F. E. Wilson.

Type, HOLOTYPE male in Coll. F. E. Wilson.



Wings: *Thaumatoperla robusta* Till.

Thaumatoperla robusta Till.

We give here Tillyard's description of this species, and add to it some further data. The female was described in Proc. Linn. Soc. N.S.W., 1921, vol. 46, p. 226; and the male in Trans. roy. Soc. S. Aust., 1924, vol. 48, p. 192.

Female, " total length, 29 mm.; abdomen (dried), 17 mm.; forewing, 22 mm., *hindwing,* 20·5 mm., expanse, 47 mm.

Head, shiny black above, with a small yellowish spot on each side of the frontal suture, just below and inwards from the base of the antennae, a transverse narrow band of olive-greenish on the labrum, and a slight touch of

yellowish-brown on mandibles and maxillae; *genae* orange-brown; *labium,* dull-brownish. *Eyes,* dark olive-grey. *Antennae* 17 mm. long, black, composed of 50 or more joints.

Thorax. Pronotum, rich orange, the convex anterior border somewhat darkened; length of pronotum, 4·5 mm., breadth, 7·5 mm., the latter greatest anteriorly; *prosternum,* yellowish-grey. *Meso* and *metathorax,* black, with a band of pale-brown between the bases of the forewings; this colour extends on to the basal dilated portion of the costal space of the forewings, and carries golden hairs on both the thorax and wings. *Legs,* black, the fore femora pale-brown on anterior border and part of the underside; the middle and hind femora with these same parts coloured more greyish-yellow. *Wings,* uniformly dull-blackish, except for the small patch of pale brown at base of costal space of forewings, already mentioned.

Abdomen, broad, nearly cylindrical, somewhat flattened, black.

Cerci (apparently with some distal joints missing), with fifteen or more short joints, the basal ones shorter than the more distal, and all carrying cilia; colour black."

Male, ' hitherto undescribed, differs from female as follows:—Total length of body 19 mm.; *forewing,* 18 mm.; *cerci,* 18 mm. The parts of the meso and metathorax, coxae, and femora, which were described as either brown or greyish-yellow in the female, are bright yellow in the male. Segment No. 9 hollowed out posteriorly above, broadly yellow on either side. Tenth tergite narrowly yellow. Supra-anal plate with a forwardly curved copulatory hook, rather short; paraprocts short, blunt.'

We desire to confirm, and add the following:—Measurements of *Prothorax,* width, 7·5 mm.; length, 5·5 mm. The latter dimension disagrees with Tillyard's who gives it (length) as 4·5 mm. Evidently he omitted to include the posterior margin beyond the ridge. For better comparison of *T. robusta* with *T. alpina* and *T. flaveola,* we give the colours from Ridgeway, as follows:—*Prothorax,* burnt sienna; *meso-thorax,* black, with a band of cinnamon buff. Anterior wings, bister, dull. *Posterior wings,* warm sepia, shiny.

R. J. Tillyard in his " Revision of the Family Eusthenidae ", Proc. Linn. Soc., N.S.W., 1921, vol. 46, p. 224, forms three new subfamilies within it, giving the following key:—

1. Wings very short and broad, the forewing less than twice as long as broad; M5 in forewing very strongly formed, making an acute angle with M1-4 distally. Costa of forewing strongly dilated basally. Branches of Rs arising from R as a pectinate series of apparently separate sectors . . . . . *Thaumatoperlinae.*

—. Wings not exceptionally short or broad, the forewing always more than twice as long as broad. M5 less strongly formed, making neither a right angle nor an obtuse angle with M1-4 distally. Costa of forewing not dilated basally. Branches of Rs in forewing dichotomic, arising normally from Rs. 2

2. Stoutly built insects of red or purple colouration, the forewing less than thrice as long as broad. Cerci long, from 12 to 16 mm. . . . . *Eustheninae.*

Much more slenderly built insects of green, yellow, brown, or grey colouration, the forewing about five times as long as broad. Cerci short, from 5 to 8 mm. . . . . *Stenoperlinae.*

None of the later papers accepts the formation of these subfamilies; Tillyard himself in his paper " New Genera and Species of Australian Stoneflies " (Order Perlaria), in Trans. roy. Soc. S. Aust., 1924, vol. 48, p. 129, and, in his ' Insects of Australia and New Zealand ', 1926, pp. 116-119, makes no further mention of the above subfamilies.

P. W. Claassen in " A Catalogue of the Plecoptera of the World ", Cornell Univ. Agr. Exp. Sta. Memoir 232, 1940, pp. 19-21, does not accept or even mention any of the subfamilies cited by Tillyard in the family *Eusthenidae*.

W. E. Ricker, Indiana University, in his paper, " Some Evolutionary Trends in Plecoptera ", Proc. Indiana Acad. Sci. 1950, vol. 59, recognizes in his table of Structural Evolution, only the subfamily *Eustheninae* for Australia and New Zealand.

The authors of this paper prefer using the family *Eusthenidae* with its two subfamilies as used by Ricker (1950), who based his separation on the characters of simple gills for larvae of *Eustheninae*, and branched ones for larvae of *Diamphipnoinae*.

In our opinion, the genera in the Australian region probably belong to one continuous group, and it is difficult to find a reason for further separation into subfamilies unless later discoveries or complete life histories of these insects are studied which may give justification for separation.

Undoubtedly the genera *Thaumatoperla* Till. and *Eustheniopsis* Till. are very closely related, but *Eusthenia* West. occupies an intermediate position between them and *Stenoperla* McLach.

Key to the Species of Thaumatoperla.

1. Head not as wide as Prothorax; width of Prothorax equal to its length . . . . . *alpina*. sp. n.

   Head as wide as Prothorax, width of Prothorax greater than length 2

2. Anterior wings unicolorous, except for base of costal space. Posterior wings unicolorous . . . . . *robusta*. Till.

   Anterior wings not unicolorous; posterior wings not unicolorous . . . . *flaveola* sp. n.

As stated by Tillyard and other authors, the family *Eusthenidae* represents present-day forms of an archaic type of Stoneflies which showed affinities with the *Protoperlaria*. The characters which denote its linkage with archaic forms may be summarized as follows:—The larvae possessing five or six pairs of lateral abdominal gills; the extensive but somewhat irregular wing venation in the adults, and this affinity with the wing tracheation exhibited by the larvae. The presence of mandibulate mouth parts in the adult, and possession of a well-developed clypeus and labrum. Both pairs of wings exhibit a large number of cross veins, and in the posterior wings the anal fan is very large.

The genus *Thaumatoperla* presents extensive but somewhat irregular wing venation with a great number of small cross veins which are variable and irregular in individual wings, showing primitiveness. The extreme hind margin of the posterior wings is divided into numerous small cells, as is also the costal region of the anterior wings.

Recognizing these primitive characters, and applying them to the three species of *Thaumatoperla,* we have arrived at the following conclusions:—

1. *T. alpina* is the most archaic; this is indicated by the form of the Prothorax (width equal to length); greatest number of small cells in costal region of the anterior wings, and extreme hind margin of the posterior wings.

2. *T. robusta* becomes intermediate in position; the Prothorax is distinctly broader than long, the number of small cells in the costal region of the anterior wings is reduced as is also the case for the extreme hind margin of the posterior wings.

3. *T. flaveola* may be regarded as the least primitive of the three species. A slightly greater reduction in length of the Prothorax as compared with its width is evident; the costal region of the anterior wings shows fewer cross veins. The same applies to the extreme hind margin of the posterior wings where only a few short veins connect the last anal vein with the hind margin.

ACKNOWLEDGMENTS.

Thanks are due to Mr. F. E. Wilson, Hon. Associate in Entomology to the National Museum, for the loan of his specimen of *Thaumatoperla flaveola* for description and study; also for valuable information and data; and to Mr. J. Brownlie, of Elsternwick, Melbourne, who collected the specimen of *Thaumatoperla alpina* and data supplied with it, and for his generous action in presenting this interesting specimen to the National Museum.

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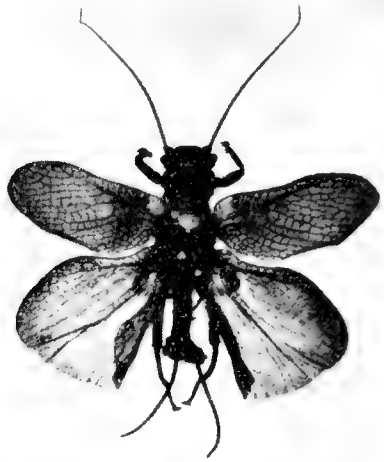

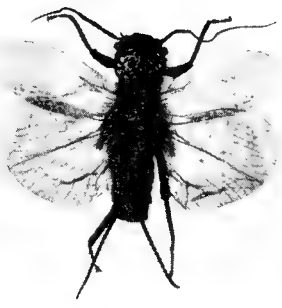

1. *Thaumatoperla robusta* Till. Female.
2. *Thaumatoperla alpina* sp. nov. Female. (Holotpye).
3. *Thaumatoperla flaveola* sp. nov. Male. (Holotype).

HEAVY BLACK SANDS FROM PHILLIP ISLAND, VICTORIA.

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Abstract.

An account is given of the distribution and extent of some heavy black beach sands on Phillip Island. The most extensive deposit lies on the southern coast just west of Cape Woolamai. The physical and mineralogical compositions of six samples of the bromoform-separated sand concentrates are described. They are composed chiefly of opaque particles, olivine, zircon, augite, rutile, tourmaline and garnet. A considerable proportion of the opaques, which make up more than 67 per cent. in all the samples, is limonite. No beach sands with a higher olivine content have been described from Australia. The physical and mineralogical compositions point to there being more than one source for the heavy constituents, and suggest that the immediate sources are chiefly rocks which outcrop nearby. The minerals are described, and the results of an inquiry into their origin are given. The black sand deposits are shown to have little economic value because of the low zircon and rutile contents and their restricted extent.

Introduction.

The submission to the Museum for examination of a sample of heavy black sand from Cat Bay, Phillip Island, led to an investigation of the occurrence and a search for other deposits on the island. The results of this work, and the study of the samples collected, form the substance of this paper.

Heavy mineral beach sands, commonly called "black sands" because of their dark colour, are naturally concentrated by wave and wind action, and form extensive deposits in various parts of the world. They are made up largely of minerals of high specific gravity which have withstood chemical and mechanical weathering. Large deposits, which are exploited for their zircon and rutile contents, occur along the coast of Northern New South Wales and Southern Queensland (Beasley, 1948; 1950). Zircon is an important refractory and opacifier, while rutile is used largely for coating electric welding rods and as a source of titanium metal.

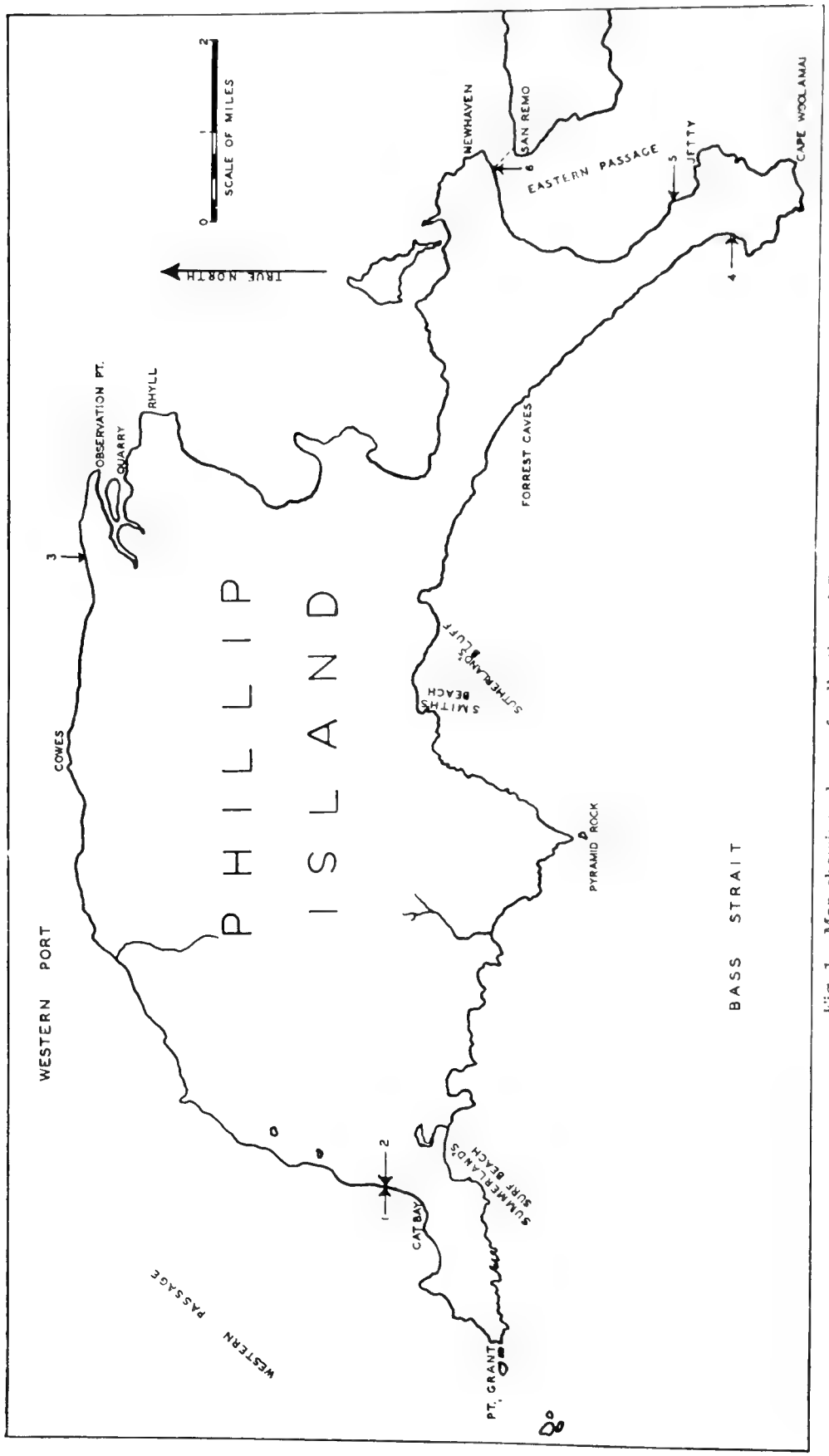

Fig. 1.— Map showing places of collection of Sand Samples.

Baker (1945, p. 12) has referred to the occurrence in patches "on some of the Phillip Island beaches in Western Port of dark-coloured beach deposits, where the dark colour is due entirely to an abundance of dark-brown to black grains of ironstone (limonite, &c.) derived from the weathering of altered basalt lavas and tuffs forming the cliffs in the immediate vicinity."

Distribution and Extent of Deposits.

The most extensive deposit located on the island was found on the southern coast just before reaching the first bluff (plate 1, fig. 1) on the western side of the Cape Woolamai headlands mass. This is some $1\frac{1}{8}$ miles N.-W. of Cape Woolamai itself, which is the extreme easterly point of Phillip Island. The deposit occurs in the upper part of the beach and takes the form of lenticular layers or seams and surface "washings," the total thickness of black sand ranging up to 1 ft. 3 in. The deposit has a length of 1,400 feet, with a maximum width of 70 feet and an average width of 40 feet. Beneath 1 to 4 inches of heavy mineral surface "washings" (plate 1, fig. 2) and a layer of white (quartz) sand a well-defined black sand seam up to 6 inches thick (plate 1, fig. 3) was found. This is underlain by white sand resting on another layer of black sand about 4 inches thick. In some of the auger holes a third black sand seam of approximately the same thickness was passed through, but in none was any found below a depth of 5 feet. Borings at right angles to the strandline have shown that the seams gradually thin out seawards, and that their greatest thickness is located about 30 feet in front of the scarp base at the top of the beach. When traced parallel to the beach in a south-easterly direction towards the headland the lower two seams were found to unite, the amount of white sand between them gradually decreasing. The heavy sand grains have been fairly well concentrated by wave action, the weight percentage of heavies in the samples collected from this deposit ranging from 28 per cent. up to 84 per cent.

A smaller deposit was found on the eastern coast of the island in the vicinity of a small bluff approximately $\frac{1}{2}$ mile N.-W. of the old Granite Quarry Jetty. It is a lenticular deposit occurring in the upper part of the beach, and consists of from 1 to 3 inches of surface "washings" and a black sand seam up to 4 inches thick beneath a layer of white sand (plate 1, fig. 4). The deposit measures some 300 feet in length and 40 feet in width.

The only deposit of any size on the northern coast of the island occurs near the eastern end of Cat Bay. It lies on both sides of the mouth of the small, spring-fed creek that enters the sea

about ½ mile N.-E. of the old Cat Bay jetty. The deposit is approximately 300 feet long but the maximum width is only 30 feet and the total thickness of black sand does not exceed 9 inches. It occurs on and just below the surface in the upper part of the beach, the thickest individual layer measuring 5 inches.

Smaller accumulations of heavy black sand were found at a number of places on the island. At some, such as around the Newhaven end of the San Remo Bridge (plate 1, fig. 5), near Rhyll jetty, and near Observation Point, they are merely small patches of surface "washings" just above high-tide mark. Unless deposited during heavy gales or at times of exceptionally high tides, when the waves may reach far beyond normal high-water mark, their position usually does not remain fixed. Rather larger than these are several accumulations adjacent to basalt and tuff cliffs on the southern coast, as on Smith's Beach and Summerland's Surf Beach. At these places boring has revealed the presence of thin seams of black sand down to a depth of about 4 feet, as well as small patches on the surface. However, in none of the bores was more than 9 inches of black sand passed through, nor was the lateral extent of the layers found to be at all extensive.

Places of Collection of Sand Samples.

The localities of the black sand samples collected for study are given below. They are numbered consecutively from west to east, as shown in Figure 1.

1. Upper part of beach, 20 feet S.-W. of small creek mouth, Cat Bay.
2. Rills in eroding cliff face of Tertiary sediments and aeolian sand immediately behind locality 1 and approximately 12 feet above cliff base, Cat Bay.
3. Upper part of beach, surface "washings" 1 mile W. of Observation Point.
4. Seam from 6 inches to 10 inches in bore on beach 850 feet N.-W. of first bluff met on western side of Cape Woolamai headlands mass, and 16 feet seawards from cliff base.
5. Seam in bore in upper part of beach, ½ mile N.-W. of old Granite Quarry Jetty.
6. Surface "washings" immediately above high-water mark on beach, Newhaven end of San Remo Bridge.

Mechanical Composition of the Concentrates.

Sieve analysis of samples of the heavy mineral concentrate obtained from the natural concentrates by bromoform separation was carried out, as knowledge of their size distribution was required for purposes of comparison. Satisfactory comparisons cannot be made from the mechanical analysis of the natural concentrates, owing to the difference in grain size of the light and heavy constituents and the sometimes considerable local variations in the degree of natural heavy mineral concentration.

Phillip Island consists chiefly of Tertiary Older Volcanic basalts, tuffs and agglomerates. Jurassic and some Tertiary sediments, and Palaeozoic granites outcrop in smaller areas. Boring has shown that the volcanic and sedimentary rocks overlie Palaeozoic sediments. An account of the island's geology and physiography has been given by Edwards (1945).

Mechanical Analysis.

In the laboratory, the samples of natural concentrate, usually of the order of several hundred grams, were washed free of salt, seaweed, &c., dried, and then split by quartering to a bulk estimated to give approximately 40 grams of heavy minerals after bromoform separation. The samples of natural concentrate were then weighed, and heavy liquid separations were carried out with bromoform of specific gravity 2·88. The separated concentrate was weighed, and the weight percentage of heavy minerals in each sample of natural concentrate was determined (see Table II.). The bromoform-separated concentrates were shaken in a nest of sieves with a mechanical shaker for twenty minutes. The sieves used were numbers 30, 60, 72, 85, 100, 120, 150, and 240 of the British Standard Series. The resulting size fractions were then weighed, percentages calculated, and the results tabulated (Table I). Cumulative-frequency curves were constructed from this information, and the median (50 per cent.) diameter and the first and third quartile diameters were read off. From the latter figures the sorting coefficients of the heavy constituents were calculated. Where Q3 and Q1 are the third and first quartile diameters, respectively, the sorting coefficient is $\frac{Q3}{Q1}$. It expresses the measure of the average quartile spread. Thus perfect sorting equals unity, and the larger the value the more poorly sorted is the sample. Comparison and description of the samples are made from the median diameters and sorting coefficients (Table II.).

TABLE I.—MECHANICAL ANALYSES OF THE BROMOFORM-SEPARATED, HEAVY BEACH SAND CONCENTRATES.

No.	Size of Openings in Millimetres.								
	> ·500	·500–·251	·251–·211	·211–·178	·178–·152	·152–·124	·124–·104	·104–·066	< ·066
	%	%	%	%	%	%	%	%	%
1 ..	1·5	31·0	17·9	13·9	6·6	20·9	7·4	0·9	..
2 ..	0·1	4·0	8·9	19·0	12·7	39·8	13·6	1·4	0·2
3 ..	0·1	2·6	11·9	24·2	9·0	31·9	15·0	5·2	0·1
4 ..	0·7	48·4	30·1	12·6	2·6	4·5	1·0	0·1	..
5 ..	0·4	24·7	21·5	13·6	11·0	17·1	8·0	0·8	..
6 ..	0·1	3·8	8·5	14·3	7·9	37·5	24·4	3·5	..

TABLE II.—MEDIAN DIAMETERS, SORTING COEFFICIENTS, AND WEIGHT PERCENTAGES OF THE HEAVY CONSTITUENTS.

No.	Median Diameter (in Millimetres).	Sorting Coefficient.	Weight Percentage Heavies.
	%	%	%
1	0·21	1·30	29·0
2	0·15	1·23	11·4
3	0·15	1·23	43·5
4	0·25	1·28	83·7
5	0·21	1·29	40·0
6	0·14	1·21	21·2

DISCUSSION OF RESULTS.

From Table I. it is apparent that the size distribution of the heavy constituents in certain of the samples is similar. In samples 1, 4, and 5 the dominant or maximum percentage is in the 0·500 to 0·251 mm. size class, and there is a secondary maximum in the 0·152 to 0·124 mm. size class. In samples 2, 3, and 6 the maximum percentage is in the 0·152 to 0·124 mm. size class, and there is a secondary maximum in the 0·211 to 0·178 mm. size class. The mechanical analysis of the latter samples shows that

their average size is much less than that of samples 1, 4, and 5. The presence of a marked secondary maximum in each sample may suggest that there is more than one source for the heavy constituents.

From Table II. it is seen that the median diameter of the heavy constituents ranges from a minimum of 0·14 mm. to a maximum of 0·25 mm. The fact that samples 1, 4, and 5 have relatively high median values (respectively 0·21, 0·25, and 0·21 mm.) suggests close proximity to the chief source of the heavy constituents, and a relatively short detrital history for the bulk of them. The smaller median values of samples 2, 3, and 6 (respectively 0·15, 0·15 and 0·14 mm.) suggest a rather longer detrital history for these. Since sample 2 has a median diameter much less than that of sample 1, it seems clear that the Tertiary sediments and overlying aeolian sands of the Cat Bay cliff only provide some of the heavy constituents to the beach deposit there.

The heavy constituents of the samples are moderately well sorted, the coefficient of sorting ranging from 1·21 to 1·30. The less well-sorted ones are those with the higher median values (samples 1, 4, and 5). These black sands are from places near or adjacent to rock outcrops. The better sorted ones (samples 2, 3, and 6) are those with smaller median values. It is of interest to note that sample 2 is better sorted than sample 1.

Mineralogical Composition of the Concentrates.

To determine the mineralogical composition, the bromoform-separated heavy concentrates were split by quartering to a bulk of approximately 3 grams. Temporary mounts were made directly from these small samples without sieve division into two size fractions. Except where accurate tests for refractive index were made, liquid with a refractive index of 1·67 was used for the temporary mounts. The heavy particles were identified under the microscope, and the number percentage of the various species was determined on the basis of a count of about 350 grains. Because of the difficulty of distinguishing between ilmenite and magnetite under the microscope and deciding definitely between limonite grains and partly altered rock particles, the black and brownish-coloured opaque particles were counted together and the combined grain number percentage of them calculated. The results of the grain counts are given in Table III.; the symbol " * " is used to indicate that the mineral is present in an amount less than 1 per cent. Permanent mounts of the heavies were made in Canada balsam, and placed in the Museum collection (Nos. E.1662 to E.1667).

The weight percentage of heavy constituents in the samples ranges up to 83·7 per cent. (Table II.). The light constituents are mainly quartz and shell fragments.

The following abbreviations are used in Table III:—

Op-, opaques except leucoxene; Ol, olivine; Zir, zircon; Aug, augite; Ru, rutile; Leu, leucoxene; Tour, tourmaline; Gar, garnet; Hyp, hypersthene; Epi, epidote; Top, topaz; Mon, monazite; Sph, sphene; Spi, spinel; St, staurolite.

TABLE III.—MINERAL ANALYSES OF THE HEAVY SAND CONCENTRATES IN GRAIN NUMBER PERCENTAGES.

No.	1.	2.	3.	4.	5.	6.
Op	65·3	76·4	70·4	78·9	78·3	79·5
Ol	10·4	4·0	9·4	5·7	3·9	3·2
Zir	6·2	10·9	4·0	4·1	6·1	11·0
Aug	7·6	1·0	6·4	2·8	1·2	0·6
Ru	3·9	5·4	1·2	2·1	1·1	1·2
Leu	2·0	1·4	4·0	1·0	2·2	1·4
Tour ..	3·2	*	3·6	2·4	1·7	1·8
Gar	*	*	*	1·9	1·5	1·0
Hyp ..	*	*	*	*	..	..
Epi	..	..	*	..	*	..
Top	*	*	*	*	..	*
Mon ..	..	..	*	*	..	*
Sph	..	..	..	*	..	..
Spi	*	*	..	..	*	*
St	*	*	..	*	..	*

The above Table shows that the heavy concentrates are composed chiefly of opaque particles, olivine, zircon, augite, rutile, and tourmaline. All the other minerals together make up less than 5 per cent. of the concentrates, garnet being the most abundant.

Opaques are the principal constituents of the concentrates. They comprise more than 67 per cent. in all the samples. Although a considerable proportion of them is made up of limonite grains, magnetic tests and optical examination have shown that particles of magnetite and ilmenite are fairly common. Magnetite was found to be more abundant in samples 4 and 5 than in the other samples. Leucoxene is present in amounts ranging from 1 per cent. in sample 4 (Cape Woolamai) to 4 per cent. in sample 3 (Observation Point), and many of the ilmenite grains show partial alteration to leucoxene. Some of the opaques were found to be small particles of weathered basalt.

Olivine is next in abundance to the opaques in one-half of the samples studied, zircon being next in abundance to the opaques in the other samples. Minerals such as hypersthene, epidote, topaz, monazite, sphene, spinel, and staurolite, where present, occur only in very small amounts; fewer than 4 and sometimes only 1 grain of some of these species were seen in the assemblages grain-counted.

There is a general similarity in the mineralogical composition of the samples. However, some of the changes in the percentages of various minerals are notable.

It will be seen that the olivine and augite contents are higher in sample 1 (Cat Bay) than in any of the other samples. This is apparently related to the larger occurrence of basic volcanic rocks in the vicinity as compared with the places of collection of the other samples. Sample 6 (Newhaven) has a zircon content higher than that of any of the others. This may be due to the fairly close proximity of Jurassic sediments and also of Devonian granite. The zircon and rutile contents of sample 2 are notable particularly as they are much greater than those of sample 1. This suggests that the Tertiary sediments of the cliff are not the sole contributor of heavy constituents to the beach deposit there.

Description of the Minerals.

Limonite.—The limonite particles appear yellowish-brown to reddish-brown and dark brownish-black under reflected light. They vary considerably in size, some being quite large. Usually they are irregular in shape, and few are well rounded. An appreciable number of the grains is strongly magnetic, but a larger percentage is not attracted by a horseshoe hand magnet.

Magnetite.—Many of the magnetite grains are irregular in shape, but some have quite regular outlines. The degree of roundness varies considerably, the smaller grains usually having

the higher degree. Octahedral crystals are scarce and dodecahedral ones are very rare, but many of the grains show remnants of crystal faces. Faceting is clearly visible on the surface of some grains. Some partial alteration to limonite is often seen.

Ilmenite.—The ilmenite grains generally have a higher degree of roundness than the magnetite and limonite; many are rounded and some are well rounded. Commonly the grain shape is irregular. Partial alteration to leucoxene can been seen in some grains.

Leucoxene.—The leucoxene grains appear dull-white to yellowish-white in reflected light. Usually they are rounded or well rounded. In size they are generally much smaller than the limonite grains.

Olivine.—Most of the olivine grains are irregular in shape and their degree of roundness is not high. The particles vary considerably in size, some being quite large. The colour ranges from almost colourless to yellowish-green. Many of the grains appear quite fresh, but some show traces of decomposition and others are quite clouded. Minute inclusions are fairly common in some grains, many being iron-ores. Euhedral crystals are rare and subhedral ones scarce.

Zircon.—Almost all of the grains are colourless; yellow ones are rare. The number of rounded grains is slightly greater than the number of euhedral and subhedral ones in the samples. Inclusions are not very abundant; they are rarer in the rounded than in the euhedral and subhedral grains. This may be because the inclusions are points of weakness in the crystals, and abrasion liberates them. The grains are considerably smaller than most of the olivine grains.

Augite.—Most of the grains are shades of brown including pale purplish-brown, but some are greenish and greyish. The degree of roundness usually is not high, and the shape generally is irregular. Some of the grains are fairly large, and most are slightly pleochroic. Some grains are clouded from decomposition, and inclusions may be abundant.

Rutile.—Foxy-red coloured and yellow-coloured grains are present, and some are dark reddish-brown and almost black. The foxy-red variety is the most common type. The grains generally are rounded, although edges of prism faces often can be seen. Inclusions are rare, and pleochroism is weak. The grains are about the same size as the zircon.

Tourmaline.—The tourmaline grains commonly are brown, but some are grey and a few are blue. Some are well rounded, and have a high sphericity. Prismatic crystals showing only slight abrasion are also present.

Garnet.—Most of the garnet grains are pink, but there are some colourless and a few brown ones. Usually they are subangular and are irregular in shape. Some show surface etching, but this is much less common than in the garnet of Queensland heavy mineral beach sands described by Beasley (1950, p. 79). Most of the garnet is the variety almandine. It is moderately magnetic.

Hypersthene.—The rare grains of hypersthene occur as elongated prisms with rounded terminations and as irregularly-shaped particles which are pale brownish-green to greyish-green in colour. Inclusions are common, most being dark-coloured. The grains display the characteristic pleochroism, and are about the same size as the augite. The degree of roundness is not very high.

Epidote.—The epidote grains are greenish-yellow and subangular or subrounded. Pleochroism is distinct but weak.

Topaz.—The rare topaz occurs as colourless, irregularly-shaped grains which are subangular or subrounded.

Monazite.—The monazite grains are pale-yellow, and usually well rounded.

Sphene.—The grains of this mineral are pale-brown, subangular, and irregular in shape.

Spinel.—The spinel group mineral, ceylonite, occurs as bluish-green, rounded grains which usually show traces of the octahedral habit.

Staurolite.—The rare grains of staurolite are irregular in shape, brownish-yellow, and moderately pleochroic. Inclusions are fairly numerous.

Origin of the Heavy Minerals.

The physical and mineralogical composition of the concentrates suggests that in most cases the immediate sources of the heavy constituents are chiefly rocks which outcrop nearby.

It seems that most of the opaques, the olivine and the augite have been derived from the Tertiary volcanic rocks which are so abundant on the island. The often quite large grain size of these

heavy sand constituents, their usually low degree of roundness and only moderate sorting suggest that their detrital history has not been very long. It is thought that many of these grains have probably not travelled far at all following their liberation from the volcanic rocks of the shore platforms, cliffs and hinterland. The presence of particles of quite fresh olivine and augite in the sands points to fairly recent liberation of such grains, since both of these minerals are not very stable (Smithson, 1950, p. 14) and fairly soon become clouded from decomposition. The Tertiary volcanic rocks have been described by Edwards, and their distribution is shown on his map (1945, p. 2). They consist of flows of Older Volcanic basalts intercalated with thick beds of tuff and agglomerate. The flows are olivine-basalts chiefly of Edwards' (1938) Flinders type. They contain olivine crystals up to 3 mm. in diameter and sometimes have quite large augite and magnetite and ilmenite grains. The tuffaceous material, as Edwards (1945, p. 13) has said, " is generally altered to red clay, red ochre, or laterite," and in places the basalts are also very altered. The soils derived from the weathering of these volcanic rocks contain ironstone gravel, the concretions ranging from 1 mm. to 1 cm. or so in diameter. Since this ironstone is physically and chemically resistant it often appears on the surface after erosion, and it seems likely that some of the opaque particles in the heavy black beach sands have come from this material.

The immediate source rocks of much of the zircon, rutile, tourmaline, garnet, epidote, topaz, monazite, spinel and sphene appear to be the Jurassic and Tertiary sediments of the island and the neighbouring mainland. Jurassic sediments consisting largely of friable arkose and felspathic grits outcrop to the west of Rhyll, and are described by Edwards (1945, p. 11). A sample of arkose from the quarry in the cliff face (see map) was found to contain 1 per cent. of heavy minerals, the suite containing grains of the above minerals very similar in general appearance to those found in the beach sands. Their size is approximately the same as in the black sands; it is much smaller than most of the olivine, augite, and opaques. There are the same colour-varieties of garnet, tourmaline, and rutile as are present in the beach sands, which points to the Jurassic sediments as source rocks for these minerals.

Tertiary sediments outcrop at certain places along the coast such as at the Cat Bay black sand locality. The ferruginous sediments which outcrop in the cliff at Cat Bay, overlying decomposed basalt, resemble the " Red Beds " above Older Volcanic basalts at Stony Point and at Corinella Point, on the western and eastern shores of Western Port. The heavy mineral

assemblage of the Cat Bay material was found to contain the species present in the arkose, with the same colour-varieties and only slightly smaller grain size. Many of the grains show a fairly high degree of roundness and clearly resemble those in the beach sands. Although opaques are the most abundant of the heavy constituents in the assemblage, and limonite the most common, there is an absence of large particles of them and also of olivine and augite.

The Devonian granites which outcrop at Cape Woolamai and at Pyramid Rock contain zircon, rutile, tourmaline, and iron ores; and it seems that some of the grains of these minerals in the beach sands have come directly from the disintegration of these rocks. The granite and the rocks of its contact aureole appear to have provided most of the minerals in the Jurassic arkose. They are thus the primary source of the majority of the grains of this suite (zircon, rutile, tourmaline, garnet, &c.) of heavy minerals in the beach sands.

Although there are no outcrops of Palaeozoic sediments on the island to provide minerals by direct weathering to the beach sand, they have been found *in situ* in deep bores, as xenoliths in the granite outcrops and as pebbles on the ocean beaches. It is thought that they form the sea-bed at least between Pyramid Rock and Cape Woolamai. These rocks, which are believed to be Ordovician in age, contain zircon, tourmaline, rutile and iron ores; and it seems likely that some of the smaller and more rounded grains of these species in the arkose, the Tertiary sediments, and the beach sands have come from them. Since these heavy minerals are of a granitic nature, their primary source must be pre-Ordovician granite. Thus, some of the grains in the beach sands have probably passed through at least four cycles of erosion, transportation and deposition.

Conclusion.

The work carried out indicates that the deposits of heavy black sand on the island have little economic value. Unfortunately, the zircon and rutile contents are too low, and the extent of the deposits is too restricted to warrant exploitation, except perhaps on a very small scale.

The position of the most extensive deposit (on the southern coast just west of Cape Woolamai) is due largely to the configuration of the coastline, with exposure to the full violence of south-westerly gales, and the presence of a sandy beach stretching from

near Forrest Caves to the beginning of the Cape Woolamai headlands. Particularly during south-westerly gales which last sometimes for several days, powerful waves strike the coast obliquely, and sand is moved eastward towards the headlands which act as a barrier and provide a place before them for the natural accumulation of the heavy minerals. There the heavy minerals have been well concentrated by wave action into seams, the rest of the beach being left impoverished. Because of its location, and its manner of formation by waves reaching far beyond normal high-water mark, the deposit has become fixed.

The Phillip Island heavy black sands are very different from the zircon-rutile-ilmenite sands of Eastern Australia (Beasley, 1950). No beach sands with a higher olivine content have been described from Australia. The physical composition of the sand concentrates and their mineralogical composition point to there being more than one source for the heavy constituents; and the inquiry into the origin indicates that weathering of the rocks of the island and neighbouring mainland has provided the various heavy ingredients of the black sands.

Acknowledgment.

I am indebted to Mr. H. A. B. West, of Cowes, for conducting me to the Cat Bay black sand locality, after sending a sample from it to the Museum. Mr. West also kindly conducted the author and Mr. E. D. Gill to the quarry in Jurassic rocks near Rhyll.

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EXPLANATION OF PLATE I.

Fig. 1.—Sandy beach south-east of Forrest Caves, looking towards Cape Woolamai. The black sand deposit lies just before the first bluff, near the centre of the left-hand edge of the photograph.

Fig. 2.—Surface " washings " at site of black sand deposit shown in photograph on left, on southern coast just west of Cape Woolamai.

Fig. 3.—Excavation showing black sand seam 6 inches thick in deposit on southern coast just west of Cape Woolamai.

Fig. 4.—Excavation showing 1 inch of black sand surface " washings " and a seam 3 inches thick in deposit approximately ½ mile north-west of old Granite Quarry Jetty.

Fig. 5.—Small patch of black sand surface " washings " around high-tide mark near Newhaven end of San Remo Bridge.

Fig. 6.—Storm-wave platform cut in granite near Cape Woolamai.


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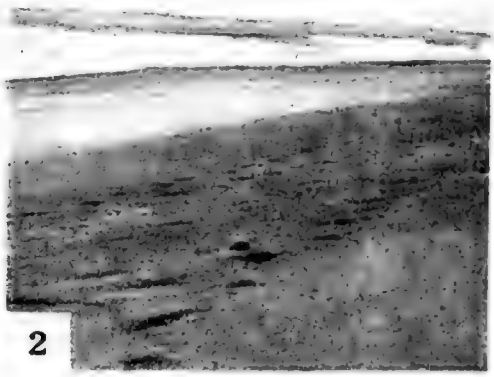
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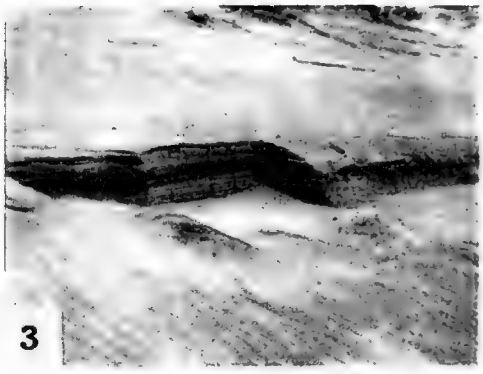
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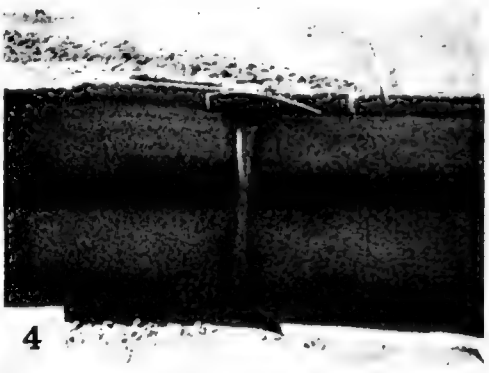
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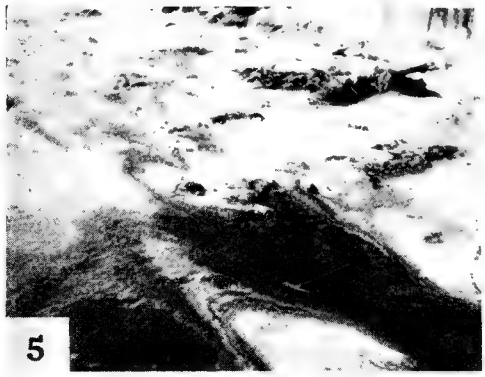
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PLATE 1.

ON NEW AUSTRALIAN SPECIES OF TROX (COL.).

By Dr. E. Haaf, Museum G. Frey (Munich).

My revision of the Australian members of the Genus *Trox* which I started about one year ago, has been published in the Entomol. Arbeiten Mus. Frey, Munich, v. 2, 1954. The present notes and descriptions complete the mentioned paper, and were made possible only by the kindness of Mr. A. N. Burns, Melbourne, who generously made available the specimens of the National Museum of Victoria for examination. In this connexion I would like to thank Director R. T. M. Pescott, Mr. Burns, and his Assistant Curator A. Neboiss.

TROX OVALIS sp. n. (Plate I., fig. 1).

A black species of moderate size and with short wings.

Head with two transverse tubercles on the forehead. Apex of the clypeus acute.

Pronotum strongly convex. Lateral margins bisinuated. Posterior angles little rounded. The central pair of the discal ridges strongly elevated diverging in a curve in the middle of the pronotum, the next pair interrupted in the middle, the lateral tubercles comparatively strong. Scutellum small.

Elytra oval, base nearly straight without humeral callus, the small teeth on the lateral margins obtused, towards the apex crenulated. The tubercles of the elytra are more or less rounded to oval except four or five near the base of the first row which are elongate, forming a costa to the middle of the elytra. The tubercles on the intervals small and much less elevated. Anterior tibiae with only a single small tooth which is placed on the outer edge one-third from the apex.

Holotype (female) in the National Museum of Victoria, Melbourne.

Length, 12 mm.; breadth, 6·5 mm.

Hab. "Alligator River", Australia.

This species belongs to the group characterized by short wings and differs from *T. tasmanicus* Blackburn and *T. elongatus* Haaf by the strongly bisinuate margins of its pronotum.

TROX ROTUNDULUS sp. n. (Plate I., fig. 2).

A comparatively large, unwinged species, notable for it characteristic form and sculpture of the elytra.

The head is regularly and deeply punctured without frontal tubercles. The apex of the clypeus acute.

The pronotum only less convex with large and small punctures, laterally granulated, margins crenulated, moderately curved and very feebly sinuated near the hind angles, converging to the apex. The two pairs of longitudinal ridges are slender, the inner pair does not extend to the base. Scutellum very small, deeply sunk in the base of the elytra.

Elytra soldered together forming a circle, without a humeral callus. Lateral margin granulated with elongate, hair-like setae. The first row of tubercles on the elytra is elevated and the small tubercles are confluent longitudinally forming a long carina and ending in a single large tubercle. The next row is distinct but not confluent bearing only a large tubercle like the first row. The intervals have still smaller tubercles, also a double row of punctures with small granules near the rim. Besides the apical tooth, which is bifid, there are three very strong external teeth on the front tibiae.

Length, 19 mm.; breadth, 12 mm.

Central Australia.

Holotype (male) in the National Museum of Victoria, Melbourne.

This species, of which I have seen only one specimen, is remarkable for the soldered, circular elytra, which bear altogether four large tubercles on the apical part and the numerous smaller tubercles running together into a costiform appearance in the first principal row. *T. rotundulus is very distinct* from any other species known to me but it is perhaps nearest to *T. elderi* Blackburn (Plate I., fig 3), which however, differs from it by the larger size and much larger tubercles in the first, second, and third row on the elytra. It differs from *T. gigas* Harold and *T. regalis* Haaf by the non-dentate lateral margins of its elytra.

TROX ELDERI Blackburn (Plate I., fig. 3).

This is a very rare unwinged species. The characters are not easy to express in words in respect to the other related species. Therefore I should add the photograph.

TROX GIGAS Har. (Plate I., figs. 4-6).

The comparison of more specimens of *T. gigas* Har. with examples of which I redescribed in my revision is of particular interest in view of the variation of this species. The hitherto unknown forms undoubtedly belong to the same species but differ from the typical feature (fig. 5) by the following characteristics: The teeth on the lateral margins of the elytra are smaller and much numerous (fig. 4) or the central pair of the longitudinal ridges of the pronotum are broader and obtused (fig. 6).

TROX STRZELECKENSIS Blackb.

The collection of the Nat. Mus. of Victoria contains some specimens belonging to *T. strzeleckensis* Blackb. Two of these differ from the type by the sculpture and size. The humeral callus is granulated, the tubercles of the first principal-row are less numerous but larger and shining. The intervals on the elytra have much smaller tubercles.

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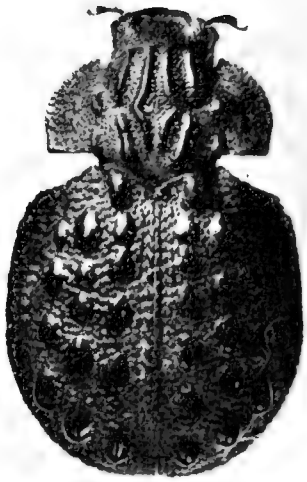

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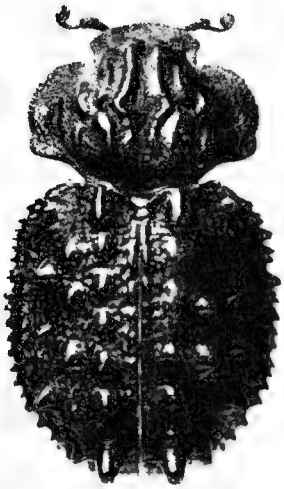

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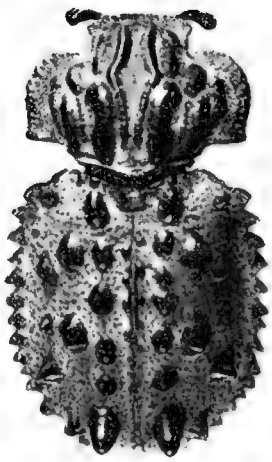

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PLATE 1.

EXPLANATION OF PLATE I.

Fig. 1.—TROX OVALIS sp. nov. Holotype (female) Nat. length, 12 mm.

Fig. 2.—TROX ROTUNDULUS sp. nov. Holotype (male) Nat. length, 19 mm.

Fig. 3.—TROX ELDERI Blackb. Nat. length, 24·5 mm.

Fig. 4.—TROX GIGAS Har. Nat. length, 23 mm.

Fig. 5.—TROX GIGAS Har. Nat. length, 25 mm.

Fig. 6.—TROX GIGAS Har. Nat. length, 23·5 mm.

The photographs were taken by Mrs. L. Dorfmüller-Laubmann, Munich (Germany).

TERTIARY MARSUPIALS FROM VICTORIA, AUSTRALIA.

By Professor R. A. Stirton, Museum of Paleontology, University of California, U.S.A.

Text-figures 1-6.

Introduction.

Three localities in Victoria have yielded mammalian fossils of Tertiary age, and a fourth a fossil of possible Tertiary age. These specimens have been referred to in literature, but there is no detailed description of their characters. Though only one new name is proposed at this time, the specimens are illustrated and described for future reference.

One of these from near Ballarat is described as a new genus and new species. It is apparent that two other new genera are represented here under the heading Diprotodontidae and in all probability generic characters will be discernible in them even when other closely related genera have been described. But in introducing generic names the binomial system must be used, and it is doubtful if characters on the specific level can ever be recognized in these specimens except possibly in Nos. P.15910 and P.15909 from Beaumaris. Furthermore this procedure seems appropriate since it is doubtful whether more diagnostic materials representing these forms will be found in the localities from which they came, and if they are discovered, new names with adequate descriptions can be made at that time. Therefore to avoid confusion for taxonomists and stratigraphers in the future I have not applied the binomial system of nomenclature to these interesting fossils.

Mr. R. T. M. Pescott, Director, and Mr. Edmund D. Gill, Curator of Fossils, National Museum of Victoria, kindly loaned the specimens to the author for study. Assistance in making available comparative materials was given by Mr. Harold O. Fletcher, Curator of Fossils, and by Mr. Ellis Troughton, Curator of Mammals, Australian Museum, Sydney. I am grateful to Mr. Hobart M. Van Deusen, American Museum of Natural History for measurements of Recent specimens. The shaded illustrations were prepared by Mr. Owen J. Poe, staff artist of the Museum of Paleontology, University of California, while text-figures 6 and 3B were sketched by the author. A Fulbright Award in 1953 made this study possible.

Fossil Podsol, Grange Burn, Near Hamilton.

PHALANGERIDAE.

Text-figure 1.

Text-fig. 1. PHALANGERIDAE, right upper molar, natural size; Nat. Mus. Vict., No. 15777; *hy*, hypocone; *me*, metacone; *pa*, paracone; *pr*, protocone. A. Labial view. B. Occlusal view.

Cuscus, Gill, 1953A, p. 409.

"*Cuscus* type", [1]Gill, 1953C, p. 107.

cf. *Cuscus*, Gill, 1955, pl. 1, figs. 1-4.

Mr. Edmund D. Gill discovered this upper molar in a fossil podsol under a basalt member where the Grange Burn flows off the basalt on to Tertiary rocks near Hamilton, Victoria. The site was 6 inches under the basalt and near a waterfall, 1 mile upstream from Forsyth's Bank. He referred it to the Upper Pliocene.

This is the crown of a moderately worn right molar without roots. Nat. Mus. Vict. reg. No. P.15777.

Paracone higher and larger than metacone (but measured from base of enamel this is not true); protocone and metacone so well worn commissures at labial base not observable; low but distinct crests extend from paracone and metacone down toward protocone and hypocone; tooth too much worn to show any indication of a crenulated surface; no cingula.

Measurements.	*Phalanger maculatus nudicaudatus.* Amer. Mus. Nat. Hist. No. 153611 ♂		No. 153615 ♂		*Phalanger orientalis peninsulae.* Amer. Mus. Nat. Hist. No. 154439 ♂		No. 154437 ♂		Hamilton Fossil.
	M^2.	M^3.	M^2.	M^3.	M^2.	M^3.	M^2.	M^3.	
Median length	5·8	5·7	6·3	6·3	1·8	4·5	4·8	4·8	8·2
Width across anterior moiety	4·9	4·7	5·1	4·9	4·1	4·0	4·4	4·1	7·8
Width across posterior moiety	4·5	4·1	4·5	4·3	3·5	3·3	3·6	3·4	6·5
Height of paracone from base of enamel	2·2	2·0	2·4	2·1	1·5	1·7	1·3	1·5	4·1
Height of metacone from base of enamel	2·0	1·7	2·1	1·9	1·5	1·5	1·3	1·5	4·3

The crown pattern is much like that in *Phalanger m. nudicaudatus* (Gould). if the fossil is an M^2 or M^3. It certainly is not M^4 because there is an appressed surface on the posterior edge indicating a tooth was behind it. It

[1]—In the citation "*Cuscus* type" and in other similar references in synonomy in this report, it should be borne in mind the author (Gill) was attempting to indicate that the specimen in question, though showing affinity with the genus named, was not necessarily referable to that genus.

does not appear to be M^1 because the appressed area in front is too wide for P^3. Furthermore, the anterior moiety is wider than the posterior moiety.

The main difference that I see between *Phalanger m. nudicaudatus* and *Phalanger o. peninsulae* Tate and the fossil is in the size of the tooth. It is approximately twice the size of these living species. Also, the teeth seem to be relatively more elongate in the Recent forms, and there is a prominent median lingual inflection in the fossil. If more teeth were represented of this animal, other conspicuous differences should appear.

Marine Beds at Forsyth's Bank, Grange Burn, Hamilton.

STHENURINAE.

Text-figure 2.

Wallaby (*Halmaturus?*), Colliver, 1933, p. 71.

" *Macropus* in the wide sense ", Gill, 1953A, p. 409.

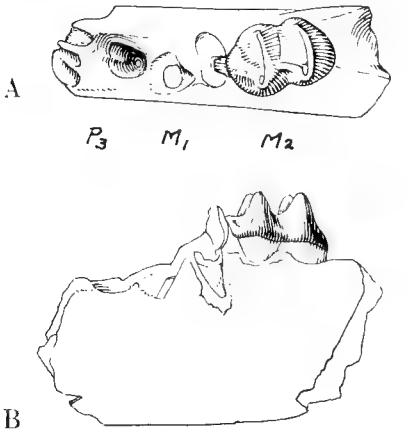
" *Macropus* type ", (2)Gill, 1953C, p. 107.

cf. *Macropus,* Gill, 1955, pl. 1, figs. 5-8.

This specimen has been referred to the Lower Pliocene by Gill (1953A).

Part of left mandible with most of alveolus for P_3; roots of M_1 and fragment of tooth; well-preserved M_2; anterior edge of alveolus of M_3. University of Melbourne, Dept. Geol. reg. No. 2019.

Alveolus indicates P_3 larger than M_1 or M_2; M_1 smaller than M_2; no evidence for size of M_3; no evidence of position of mental foramen; M_2 rather elongate; narrow, median anterior shelf-like cingulum; low forelink extends to anterior cingulum from protoconid; protolophid sharp, slightly crescentic; median valley V-shaped; low midlink extends down to bottom of median valley from hypoconid; hypolophid sharp, slightly crescentic; posterior end of tooth with slight posterior extension at lower enamel border; no postlink; enamel surface not pitted or finely grooved.



Text-figure 2.

STHENURINAE, part of left mandible, natural size; Univ. Melbourne Dept. Geol., No. 2019. A. Occlusal view. B. Labial view.

The Forsyth's Bank specimen is referable to the subfamily Sthenurinae in all of the characters of its M_2. The described species referable to that subfamily

(2)—See footnote 1.

are *Sthenurus atlas* (Owen, 1873; 1874) from the Wellington Cave (genotypic species), *S. pales* DeVis (1895) and "*Sthenurus*" *oreas* DeVis (1895) from the Darling Downs region, and "*S.*" *occidentalis* Glauert (1910) from the Mammoth Caves of Western Australia. The Victorian specimen is probably more distantly related to the much smaller "*Halmaturus*" *vishnu* DeVis (1895) and "*Halmaturus*" *odin* DeVis (1895) from the Darling Downs region which also have *Sthenurus*-like molars but narrow rather trenchant premolars. The alveolus for the premolar in the Forsyth's Bank animal appears to have been too large and bulky for either *vishnu* or *odin*, and is more suggestive of those in the species listed above. The generic and specific relationships of the specimen at hand cannot be determined until a premolar is found. Unfortunately neither the stratigraphic position nor the exact geographic location of the types mentioned above from the Darling Downs region have been established.

Measurements.	*Sthenurus atlas* (topotype).	"*Sthenurus*" *oreas* (type).	"*Sthenurus*" *occidentalis* (topotype).	Sthenurinae, Forsyth's Bank.	"*Halmaturus*" *vishnu* (type).	"*Halmaturus*" *odin* (type).
Length of P_3	16·8	17·6	16·2	11·2 approx.	9·8	9·3
Length of M_1	10·8	12·1	10·3	9·7 approx.	7·2	7·4
Length of M_2	11·9	15·1	12·3	11·1	7·9	9·5
Width of M_2 across protolophid	10·5	12·3	10·1	8·2	6·7	7·5
Width of M_2 across hypolophid	..	..	10·2	8·2	..	..
Depth of mandible below anterior edge of M_1 ..	31·0	..	32·2	20·1	18·3	25·5
Height of protoconid on M_2	8·3	..	7·1	5·8	4·1	..
Height of hypoconid on M_2	9·6	..	7·3	6·3	5·0	..

Marine Sandringham Sands, Beaumaris.

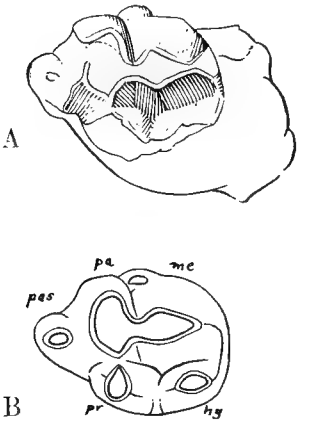
Three diprotodont (Diprotodontidae) specimens were picked up on the tide swept shore platform at Beaumaris. Two of these (M.U.G.D.2020 and P.15909) probably belong to the same species, and to a group frequently called " nototheres ", though they are not closely related to the genus *Nototherium* Owen of about the same size. The other (P.15911), described on page 127 in this report, is much more primitive and smaller. The preservation and fluorine tests of these specimens indicate that they come from the contiguous cliffs of the Sandringham Sands formation (Gill, 1950, 1953c, 1957), which constitute the type section of the " Cheltenhamian " Stage (Singleton, 1941).

DIPROTODONTIDAE.

Text-figures 3, 4.

Specimen M.U.G.D. reg. No. 2020 P^3.
Palorchestes, Hall and Pritchard, 1897, p. 58.
Palorchestes, Cudmore, 1926, pp. 81-82.
Palorchestes, Colliver, 1933, p. 71.
" *Palorchestes* type ",[3] Gill, 1953c, p. 107.
Diprotodont, Stirton, 1954a.
Specimen P.15909, part of right maxillary. Also fragment P.15910.
" *Nototherium* type ",[4] Gill, 1953c, p. 107.
Diprotodont, Stirton, 1954a.

The P^3, M.U.G.D. reg. No. 2020, though with the same preservation as P.15909, is badly abraded. Nevertheless I think its cusp arrangement can be determined (see Text-figure 3b).



Text-figure 3.

DIPROTODONTIDAE (size, medium), left P^3, natural size; M.U.G.D. reg. No. 2020, *hy,* hypocone; *me,* metacone; *pa,* paracone; *pas,* parastyle; *pr,* protocone. A. Occlusal view. B. Restoration of occlusal view.

([3])—See footnote 1. ([4])—See footnote 1.

Protocone, hypocone, paracone, metacone, and parastyle all well developed; paracone largest, not widely separated from metacone; parastyle at anterior angle of tooth; low stylar cusp in middle of labial side; basin between protocone, hypocone, and metacone; enamel surface smooth; hypocone and metacone connected posteriorly by low crest; outline of lingual and labial borders convex.

This is much like a P^3 described by Glauert from the Mammoth Caves in Western Australia. It is also similar to "*Nototherium*" *tasmanicum* Scott, but differs in details from both.

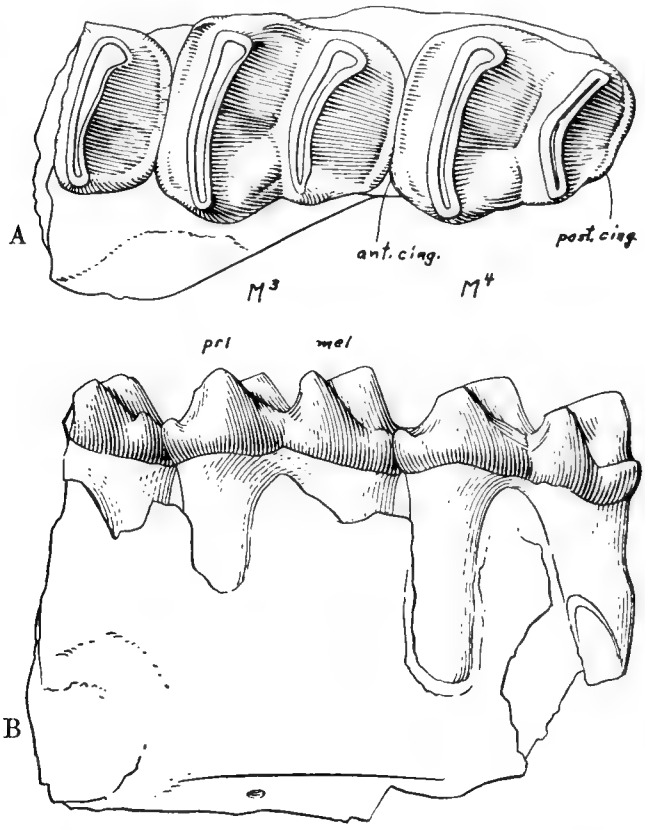
Part of right maxillary with posterior moiety of M^2 but with M^3 and M^4 complete may offer some useful information once additional data are available on other forms.

P.15909.

Teeth well preserved, slightly worn; bone abraded; jugal process M^2 and anterior moiety of M^3, low rounded ridge extends posteriorly from this process parallel to and 30 mm. above tooth row.

Measurements—

Median length	28·9 mm.
Width across middle	18·1 mm.



Text-figure 4.

DIPROTODONTIDAE (size, medium), part of right maxillary; natural size; Nat. Mus. Vict., No. 15909; *ant. cing.*, anterior cingulum; *mel*, metaloph; *post. cing.*, posterior cingulum; *prl*, protoloph. A. Occlusal view. B. Labial view.

M^2 with metaloph nearly transverse, only slightly crescentic; posterior cingulum continuous across posterior end of tooth, terminates at posterior base of metacone and at posterolingual base of hypocone, stylar cusp at posterolingual base of hypocone, stylar cusp at posterolabial corner; evidently short cingulum across lingual opening of median valley.

M^3 with anterior moiety wider than posterior moiety; protoloph transverse but slightly crescentic and slightly oblique; wide anterior cingulum not elevated at midpoint, terminates in stylar cusp at anterolabial corner of tooth, anterior cingulum as wide as protoloph, terminates lingually at anterior base of protocone; posterior cingulum not as wide as metaloph, smaller stylar cusp at posterolabial corner, not elevated at midpoint, terminates lingually at posterior base of hypocone; cingulum not continuous opposite protocone, hypocone, paracone, or metacone; short cingulum across lingual opening of median valley with small stylar cusp at posterolingual base of protocone; median valley wide; faint elevation of midlink like structure in median valley back of paracone; no stylar cusp at posterolabial base of paracone.

M^4 like M^3 but metaloph more crescentic and posterior moiety relatively and actually narrower.

Measurements—

Length M^3 to M^4	56·6 mm.
Length M^3	28·0 mm.
Length M^4	28·0 mm.
Width metaloph M^2	20·9 mm.
Width protoloph M^3	25·4 mm.
Width metaloph M^3	21·6 mm.
Width protoloph M^4	23·8 mm.
Width metaloph M^4	18·5 mm.
Height paracone M^3	12·0 mm.
Height paracone M^4	11·2 mm.

Comparison of the Beaumaris maxillary with part of a large diprotodont maxillary from the Palankarinna fauna discloses a marked resemblance. The Beaumaris form differs in the following features from the Palankarinna specimen; posterior moieties relatively narrower transversely; anterior cingula with labial cusp less developed but distinct; no stylar cusp at posterior labial base of paracone; posterior edge of jugal arch apparently opposite anterior edge of M^3.

This specimen seems to be closely related but less advanced than a larger "notothere" (Stirton, 1954B, p. 1308) from Palankarinna. Unfortunately adequate types for these fossils are not yet available.

Specimen P.15911.

Text-figure 5.

Sthenurus (?), Cudmore, 1926, pp. 81-82.

"*Sthenurus* type",[5] Gill, 1953c, p. 107.

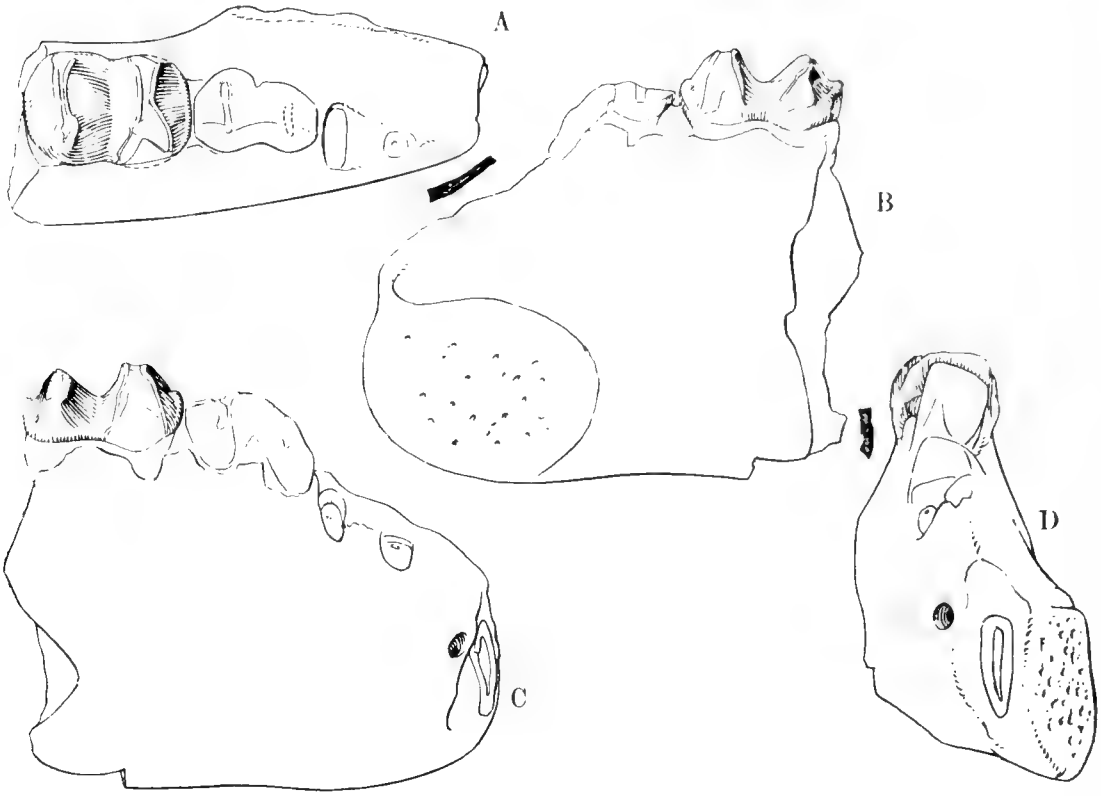
? diprotodont, Stirton, 1954A.

This specimen unquestionably represents a new genus and probably a new subfamily. It is the anterior part of a heavily abraded right mandible with part of the symphysial surface. A cross-section of the root of the incisor is observable. Part of the lower ends of the two roots of P_3 and only some of

([5])—See footnote 1.

the dentine is remaining of M_1. M_2 is fairly well preserved but the enamel is missing on the labial base of the crown and also on the labial side of the protolophid.

Posterior edge of symphysis below anterior end of M_1; P_3 two rooted; M_2 elongate, relatively narrow for any known genus in the Diprotodontidae; protolophid possibly slightly wider than hypolophid; lophids transverse and slightly crescentic; posterior cingulum relatively short, does not curve anteriorly towards base of hypoconid, elevated at midpoint, without midpoint spur connecting to base of hypolophid; anterior cingulum also short, tapers down to labial corner; slight midlink extending out from hypoconid; no forelink or hindlink; apparently no short cingula across mouths of median valley; wide median valley; base of incisor flattened laterally; small round mental foramen 16 mm. below and 5 mm. in front of P_3.



Text-figure 5.

DIPROTODONTIDAE (size, small), anterior end of heavily abraded mandible, natural size; Nat. Mus. Vict., No. P.15911. A. Occlusal view. B. Lingual view. C. Labial view. D. Front view.

There is another left mandible in the National Museum of Victoria (P.16279) from Chinchilla, Queensland. The Chinchilla specimen has P_3, M_1, M_2, and M_4 in place. P_3 is badly broken on the upper lingual surface but from the median crest there is a gently sloping labial surface and the basal cingulum which seems to be continuous around the tooth is quite distinct. The outline of P_3 is ovate but wider in its posterior half. The lower molars agree with those in *Meniscolophus* (Stirton, 1954c) in an elevation of the posterior cingulum at the

midpoint but there is no spur-like connexion across to the base of the hypolophid as occurs in the Palankarinna form. Of course the molars are much smaller, lower crowned, more elongate and they differ from all known diprotodonts in many other features. The Chinchilla form has a forelink on M_1 which may be diagnostic in this undescribed genus. The forelink is not present on the other molars. Nevertheless the massive mandible and the construction of the molars is more like the Diprotodontidae than like the Macropodidae. It is not referable to any other known family of marsupials.

Measurements—

Depth of mandible below M_2	42·7 mm.
Thickness of mandible below M_2 ..	22·9 mm.
Approximate length P_3	13·5 mm.
Apparent length M_1	15·2 mm.
Approximate width M_1	10·4 mm.
Length M_2	19·5 mm.
Width across hypolophid M_2	13·0 mm.
Approximate height of hypoconid M_2 ..	8·2 mm.

Well, Parish of Smeaton, Near Ballarat.

The mandible of a dasyurid with M_4 and the posterior root of M_3 in place was presented to the National Museum of Victoria, in 1914, by Mr. J. Marshall. Recently Mr. Edmund D. Gill found the first molar (M_1) which fits into the alveolus and contacts perfectly with the broken root in the posterior alveolus.

Though the geologic age of the specimen is not certainly known at this time, it seems that its stratigraphic position in the section at the Parish of Smeaton, can be established (see Gill, 1957). The characters in this young mandible offer additional information on the relationships of *Dasyurus*, *Dasyurops* and *Sarcophilus*.

Glaucodon[6] *ballaratensis* Stirton, n. gen. and n. sp.

Text-figure 6.

Sarcophilus? Gill, 1953B, p. 87.

Type of genotypic species.—*Glaucodon ballaratensis.*

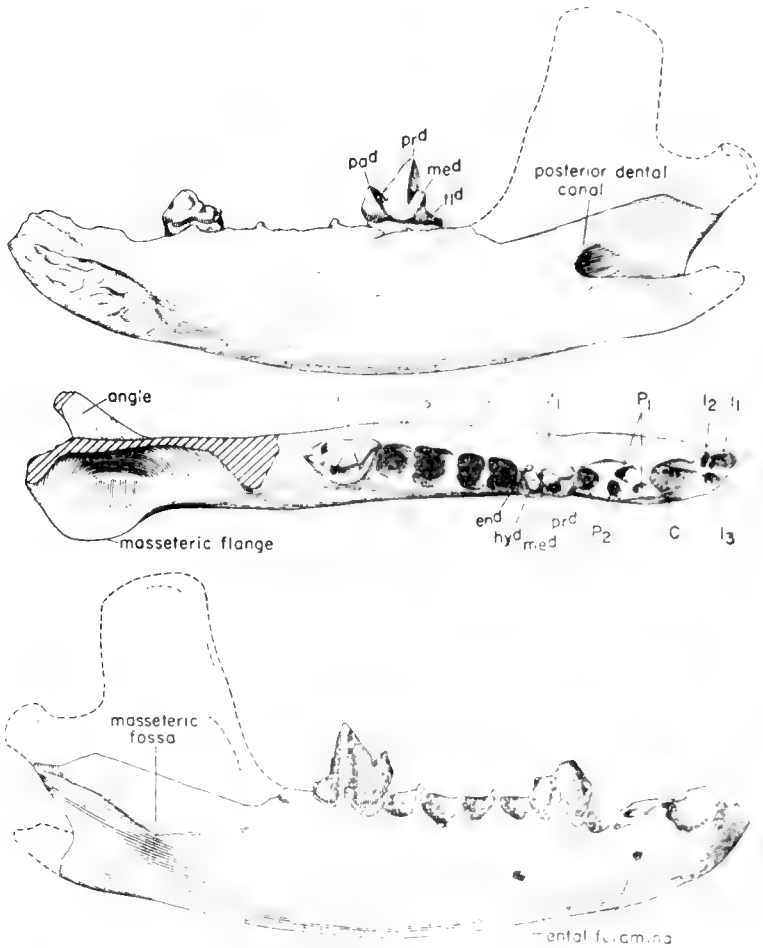
The diagnostic characters of the genus are those of the genotypic species until other species are described.

Holotype.—Right mandible with ascending ramus and part of angle missing; alveoli for three incisors, canine, two premolars and for the second and third molars; M_1 and M_4 in place. Premineralization by vivianite displaying dark-blueish colour particularly in the teeth. Animal evidently young adult. Nat. Mus. Vict. reg. No. P. 16136.

Type locality.—Taken from a depth of 50 feet in allotment 42, Parish of Smeaton, near Ballarat (for additional information see Gill 1957 of this memoir).

(6)—γλαυκός, blue; ὀδοών, tooth. Colour in type specimen.

Diagnosis and Description.—Teeth larger but length of mandible only slightly longer than in *Dasyurops maculatus* (Kerr); alveoli of incisors crowded out of line, middle one above others, inner and middle ones equal (2·1 mm. dorsoventrally), outer one about 0·1 smaller, labial edges of incisor alveoli convex, inner edges straight or slightly concave; canine alveolus large, labial edge convex, inner edge slightly concave; alveoli for premolars crowded, no



Text-figure 6.

Glaucodon ballaratensis Stirton, n. gen. and n. sp., right mandible, natural size: Nat. Mus. Vict., No. P. 16136; *en*^{d}, entoconid; *hy*^{d}, hypoconid; *me*^{d}, metaconid; *pa*^{d}, paraconid; *pr*^{d}, protoconid; *tl*^{d}, talonid. A. Lingual view. B. Occlusal view. C. Labial view.

diastems C and M_1; alveoli for P_1 [7] set oblique to anteroposterior axis of tooth row and P_2 alveoli slightly so, both teeth double rooted, alveoli for roots P_1 more posteriorly directed, those of P_2 more vertical and with posterior alveolus nearly twice as large as anterior one, alveoli indicate smaller gradation in size from M_3-M_1.

[7]—If we assume that the premolar reduction in *Dasyurops, Dasycercus,* and *Glaucodon* was the same as that in *Phascogale*, as indicated by its vestigial P_3, the remaining lower premolars in these genera are P_1 and P_2.

M_1 with heavy median protoconid, anterior median crest from base to top of protoconid, metaconid tightly appressed to posterolingual slope of protoconid, well developed talonid, hypoconid massive slightly crescentic, hypoconulid in posteromedian position at posterior end of hypoconid crescent, indication of tiny cusp of posterolabial crest of protoconid connecting across to hypoconid crescent in this stage of wear, entoconid as small rounded cusp, talonid basin with narrow lingual opening anterior and posterior to entoconid—no direct posterior opening; posterior lower labial corner extends farther posteriorly than other parts of the tooth. M_4 with high sharp paraconid-protoconid shear, protoconid much higher than paraconid, not separated by deep niche in blade, protoconid with slight backward direction, inner surface somewhat flattened with distinct vertical median ridge, metaconid much smaller than paraconid, talonid greatly reduced, small crescentic crest connecting hypoconid and entoconid, tiny posterolabial cingulum on talonid, basal cingulum on anterolabial surface. Small anterior mental foramen below anterior end of P_2, large posterior mental foramen below anterior end of M_3, opening of dental canal with 3·3 vertical diameter; lower end of masseteric fossa, angle and masseteric flange as in *Dasyurops*.

Comparison.—The characters in *Glaucodon ballaratensis* seem to indicate proximity of an intermediate relationship beween *Dasyurus quoll* (Zimmerman), the native cat, and *Dasyurops maculatus* (Kerr), the tiger cat, on the one hand and the undescribed *Sarcophilus* [8] from the Pliocene at Kalamurina from the Warburton River in South Australia on the other.

It differs from *Dasyurus* and *Dasyurops* and tends to approach the Kalamurina *Sarcophilus* in several features: alveoli of incisors crowded out of line, middle one above others, alveoli of premolars crowded, no diastems between C and M_1; alveoli for P_1 set oblique to anteroposterior axis of tooth row, and P_2 alveoli slightly so, posterior alveolus of P_2 nearly twice as large as anterior one; M_1 cusps more massive not so trenchant; M_4 with higher paraconid shear, protoconid and paraconid not separated by deep niche; protoconid with higher apex, apex with slightly stronger backward direction, and with distinct median-vertical-lingual ridge, metaconid smaller than paraconid but not vestigial; talonid greatly reduced, with less bicuspid aspect.

Glaucodon differs from the Kalamurina as well as the later species of *Sarcophilus* and tends to approach *Dasyurops*, particularly, in: proportions of horizontal ramus; shape of masseteric fossa, angle, and masseteric flange; more trenchant molars with longer and more distinctly bicuspid talonids; M_4 with paraconid shear relatively and actually lower, apex not so strongly directed posteriorly, inner surface somewhat flattened, median-vertical-lingual ridge on protoconid not as pronounced; metaconid still present not vestigial.

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[8]—The *Sarcophilus* from Kalamurina is more closely related to *S. laniarius* (Owen) from the Wellington Caves and elsewhere in Pleistocene assemblages than to the living *S. harrisii* Boitard.

Measurements.	*Dasyurus gaeli* ♂ (U. C. Mus. Pal.).	*Dasyurops maculatus* No. 66162 ♂ (Amer. Mus. Nat. Hist.).	*Glaucodon ballaratensis* Genotype No. P16136 Nat. Mus. Viet.	Pliocene *Sarcophilus*.	*Sarcophilus laniarius* composite topotype Nos. M 1261-64 (Aust. Mus.).	*Sarcophilus harrisii* No. 65670 ♂ (Amer. Mus. Nat. Hist.).
Length, anterior edge of incisor alveoli to posterior end of M_4	35·0	46·9	54·5	71·0	72·5	65·2
Length, molar series ..	20·0	25·3	34·6	44·2	49·4	41·4
Length between C and M_1 ..	8·7	13·2	10·3	11·1	13·8	10·7
Length M_4	5·3	6·6	10·0	12·8	15·0	10·7
Width of M_4	3·1	3·8	5·8	6·8	8·2	6·3
Height of protoconid of M_4 above edge of enamel of anterior root	5·2	6·4	9·1	12·4	15·2	9·8 (worn)
Depth of mandible below P_2, measured from tip of bone between roots	7·0	9·8	10·1	20·4	23·7	18·0
Depth of mandible below M_4, measured from tip of bone between roots	9·2	14·0	17·3	27·7	28·6	21·3
Thickness of mandible below M_4	4·0	6·1	6·7	11·2	12·5	10·1
Length M_1	4·5	4·9	7·6	9·2	10·6	..
Width M_1	2·7	2·9	4·2	6·1	7.1	..

Thylacynus cynocephalus (Harris) with its three premolars, absence of metaconid (as in *Sarcophilus*—evidently convergent characters), and shape of the angle seems to be rather widely removed in its relationships.

If *Glaucodon* was a dasyurid in the direct ancestry of the known species of *Sarcophilus*, judged by its stage in evolution, it could be as old as late Miocene or slightly older. If it is Pliocene or later it must represent a primitive form lingering on that shows some features of an early evolutionary stage in the group. The reduction in the size of the metaconid and of the talonid preclude its having given rise to any of the genera now known other than *Sarcophilus*. Perhaps these questions will be answered through future discoveries.

Summary.

Three localities in Victoria, Australia, have yielded five fragmentary marsupials of Tertiary age. A fourth locality near Ballarat has yielded a specimen of possible Tertiary age. A diprotodont (Diprotodontidae) of medium size and a smaller more primitive one occur in marine beds, near Beaumaris. These fossils were found on the tide-swept shore platform, but the preservation and fluorine tests indicate that they come from the contiguous cliffs which consist of beds of Upper Miocene age (Gill, 1953A, 1957). Part of a mandible with one tooth from Forsyth's Bank, Grange Burn, near Hamilton, is referable to the Macropodid subfamily Sthenurinae. It is much smaller than *Sthenurus atlas* Owen. The marine bed in which it was found, and to which it has been shown to belong by fluorine test is of Lower Pliocene age (Gill, 1953A, 1955, 1957). An upper molar of a cuscus from a fossil podsol near Hamilton, has been dated as Upper Pliocene. The tooth is nearly twice as large as in other Australian species. A dasyurid mandible from near Ballarat with one molar in place is described as *Glaucodon ballaratensis* Stirton, n. gen. and n. sp. Characters in the specimen suggest proximity to an intermediate relationship between *Dasyurops* and *Dasyurus* on the one hand and to the sarcophilenes on the other. The specimen is suggestive of a position leading toward *Sarcophilus*.

Characters in these fossil marsupials do not as yet confirm or offer evidence to question the ages assigned. This is due in part to our inadequate knowledge of the evolution in Australian marsupials. As our evidence increases, however, these records of land mammals in marine formations will be most helpful in establishing synchrony in the deposition of continental and marine stratigraphic units in Australasia.

Generic and specific names have not been applied, except in one specimen, because of incompleteness in the elements preserved and because of the confusion likely to ensue for taxonomists in the future.

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THE STRATIGRAPHICAL OCCURRENCE AND PALAEOECOLOGY OF SOME AUSTRALIAN TERTIARY MARSUPIALS.

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Paper submitted January, 1955.

ABSTRACT.

A. *Wynyardia bassiana* is a Lower Tertiary possum from Northern Tasmania whose provenance has been checked by the fluorine test and other investigations. It was apparently swept down a river and entombed as a carcase in marine calcareous mud because the bones were largely in their correct relative positions.

B. In the Hamilton district of Victoria, part of the ramus of a kangaroo in a Lower Pliocene marine bed suggests some kind of grassland environment, and indicates an older origin for the kangaroos than some have previously accepted. In a swampland environment with a conifer-eucalypt forest rich in ferns, and with ponds rich in diatoms and sponges, there lived a cuscus represented by a fossil molar. Volcanic ash fell on this landscape which was subsequently obliterated by lava flows. The climate was pluvial and warmer than the present. There is evidence to suggest that the Grampian Mountains were uplifted at this time.

C. The recognition of marine and non-marine members of the Sandringham Sands formation in the Port Phillip area, the dating of the latter member by pollen analysis, and the consideration of the varying facies involved, assist in understanding the Upper Miocene marine beds at Beaumaris whence came a number of marsupial bones. Fluorine tests have checked their provenance.

D.-E. The Tertiary marsupial fauna of Australia as at present known is listed, and a number of localities of possible Tertiary age which have yielded marsupial fossils is discussed.

CONTENTS.

Introduction.

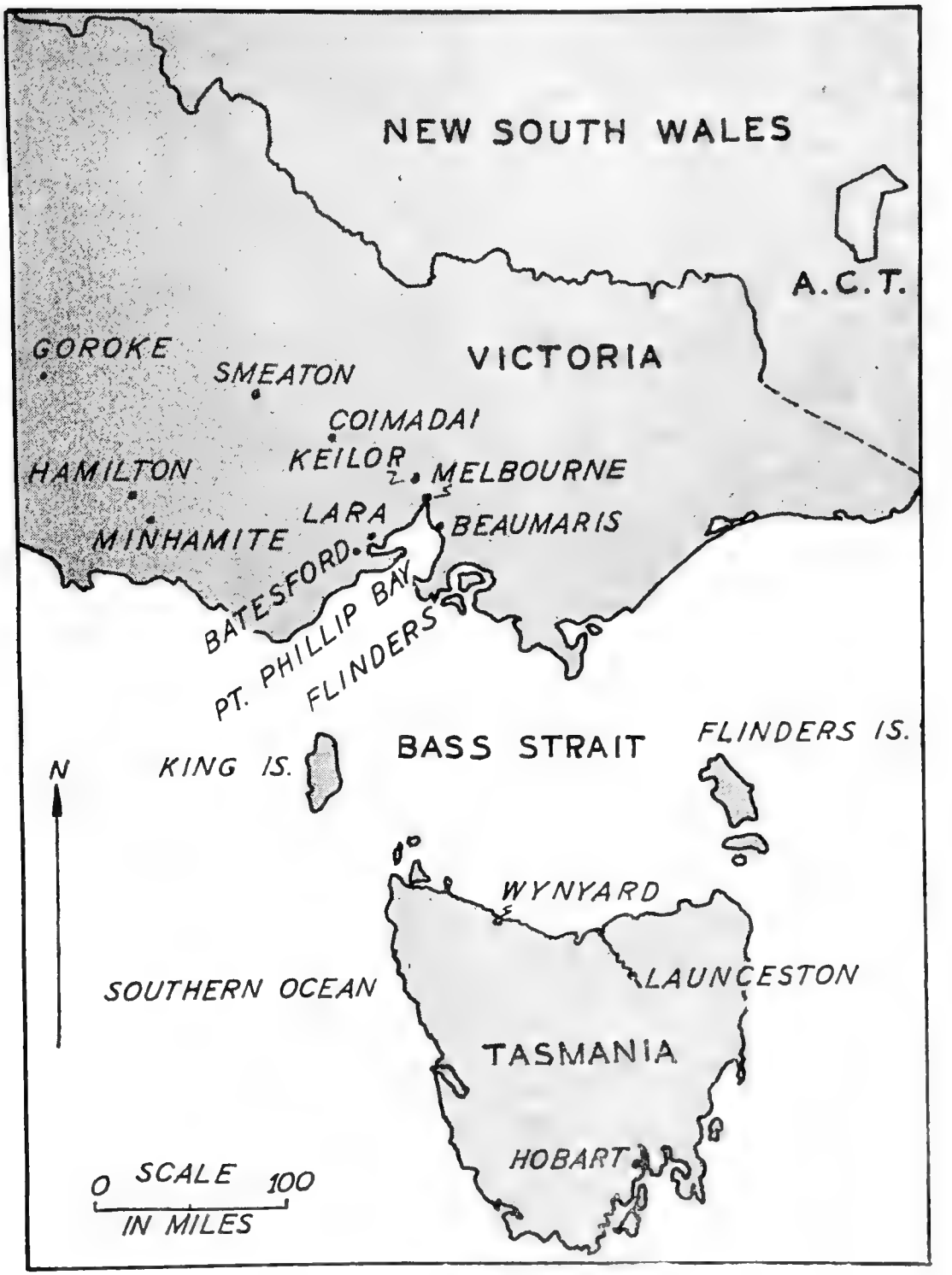
In the year 1900, Professor Baldwin Spencer published his monograph on *Wynyardia bassiana* and thus the nature of Australia's first Tertiary marsupial became known. With the help of fluorine tests, a number of others has recently been recognized, and this paper is written to elucidate their stratigraphical occurrence. Most of these marsupials occur in shallow water marine deposits and the marine fossils thus date them with some precision.

A. Occurrence of *Wynyardia* at Wynyard, Tasmania.

1. Stratigraphy.—The possum *Wynyardia bassiana* was found in the Janjukian limestone at the cliff called Fossil Bluff which faces Bass Strait at the eastern edge of the delta of the Inglis River in Northern Tasmania (see text-fig. 1). The locality is on the outskirts of the township of Wynyard, but is often referred to in the literature as Table Cape, a prominent basaltic headland a little further west. It is more accurate to refer to the site as Fossil Bluff, Wynyard. The site and its fossils have been described by Johnston (1876, 1887, 1880A, 1885A, B, C, 1888), Tenison Woods 1876A, B, C, 1877), Stephens (1870), Scott (1914), Scott and Lord (1922), Flynn (1932), Tate (1885A, B), May (1919A, B, 1922), Pritchard (1896, 1913), Chapman (1922), Chapman and Crespin (1923, 1935), Duncan (1875, 1876), Ashby (1925), and others. The writer (Gill, 1955) has commented on the palaeoecology of the beds. The site has been proclaimed a reserved area for scientific purposes (Anonymous, 1920).

The first reference in literature to *Wynyardia* appears to be that of Tenison Woods (1876, p. 28), who after describing *Turritella sturtii* stated, " In the Museum there is a large block of yellow calcareous sandstone from Table Cape, principally composed of this fossil, with an almost complete skeleton of a small marsupial herbivore imbedded. (*Macropus* or *Halmaturus?*)." Johnston (1888) mentioned it, and later Tate (1894) gave the following account:—

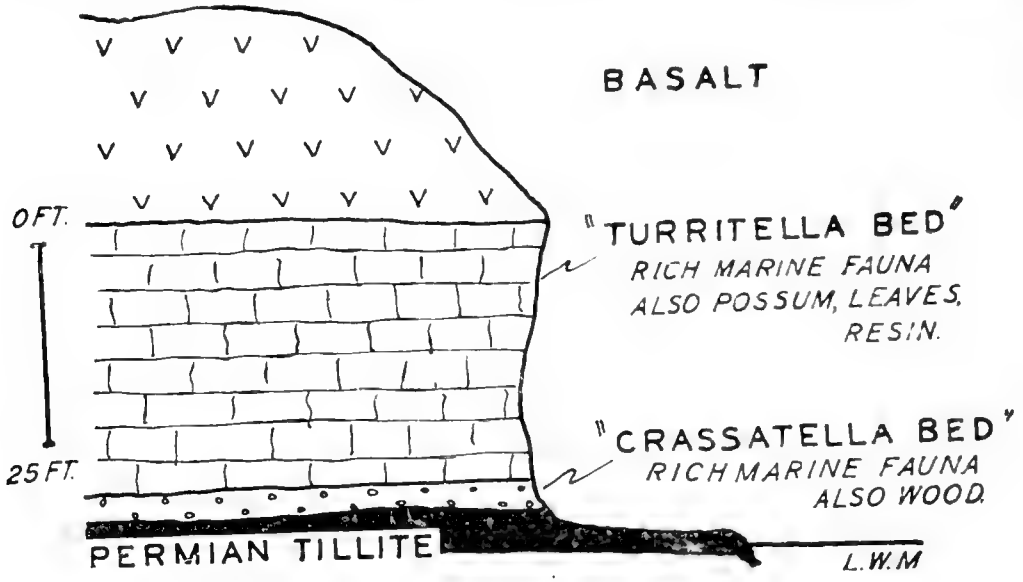
" The skeleton of a marsupial is recorded by Mr. R. M. Johnston from the ' Turritella beds ' at Table Cape, and by him referred to the living genus *Halmaturus* without specific name. At the time of writing my Census, I had thought it possible that the specimen might be of recent date, and had reached its position by way of a vertical fissure from the surface, and it was accordingly omitted. During the meeting of the Australasian Association for the Advancement of Science at Hobart, the slab containing the skeleton was carefully examined by Professors Hutton and Spencer and myself, and by us was unhesitatingly pronounced to be lying in the bedding plane of the rock. Subsequently Professor Spencer and myself visited Table Cape to study its stratigraphical features, with the result that this extensive vertical section represents one period of deposition, gradually passing from the basal conglomerates and coarse grits, rich in marine fossils, to the ' Turritella beds ', in which the species have been greatly reduced in number, and to estuarine or fluviatile beds with plant-remains only. This discovery is of the highest interest, as hitherto no marsupial remains are known older that the age of *Diprotodon* or Pliocene; and leads us to hope that other progenitors of the modern Marsupialia of this Continent may yet be found, and so help to solve the question of their geographic origin. Professor Spencer has promised to investigate the fossil with the view to determine the classificatory position of the oldest known Australian marsupial."



TEXT-FIGURE 1.—Locality map of South-East Australia.

Spencer (1900) kept his promise. One of his original drawings is reproduced in Plate 1. In 1930, Wood Jones redescribed and reinterpreted this important fossil. The references in literature to *Wynyardia* are legion, and for the present purpose it may be enough to mention the discussions by Abbie (1941), Anderson (1925, 1936, 1940), Longman (1924), Pearson (1947), and Simpson (1930). After Tate expressed his hope of further finds of Tertiary marsupials in Australia, 59 years passed before further definite records were established (Gill, 1953A, B).

The stratigraphical succession at Fossil Bluff is as shown in text-fig. 2, and the actual cliff is illustrated in Plate 2, figs. 1-2. The Tertiary sediments rest on a Permian tillite (Kitson, 1902;



TEXT-FIGURE 2.—Geological Section of Fossil Bluff, near Wynyard, northern Tasmania. *Wynyardia* came from the "*Turritella Bed*."

David, 1907; Noetling, 1909) with large drop pebbles. This tillite forms the shore platform at Fossil Bluff. Over the tillite lies the "*Crassatella* bed" without any intervening fossil soil or other evidence of subaerial weathering. The bed is about 3 feet thick at Fossil Bluff, and consists of a conglomerate containing numerous pebbles of different kinds such as can be found in the tillite underneath. In addition there is gravel, sand, and finer fractions. There is a large calcareous fraction consisting of the skeletons (mostly broken) of marine organisms (mollusca predominating). The sediments are very poorly sorted. The lithology of the beds as such has not been studied, but the above description is enough to indicate a shallow water, near-shore environment

with strong currents. The large heavy-shelled *Crassatella* was particularly successful in this habitat. Johnston (1876) reported fossil wood from this bed.

Without any apparent stratigraphic break, the "*Crassatella* bed" is succeeded by the "*Turritella* bed". M. R. Banks of the University of Tasmania and the writer visited the site and 1952 and agreed that there is no disconformity or diastem in the succession. The "*Turritella* bed" is a fine-grained clayey limestone, and the lower part of it is particularly rich in fossils. From this bed came *Wynyardia*. Of ecological interest is the fact that fossil leaves (Johnston, 1887, p. xx., plates A, B following p. 248; 1888, pp. 182, 185) and a waterworn pebble of resin (Gill, 1955) have come from this bed.

2. *Age.*—In the past 75 years many different ages have been attributed to the Tertiary beds at Fossil Bluff. Some of these differences are due to the fact that certain determinations antedate the acceptance of the Oligocene Period. Others are due to different ideas as to their antiquity. However, for some time it has been agreed that they are of Janjukian age. Raggatt and Crespin (1952) claim this stage to be of Eocene age, whereas Singleton (1941) and Glaessner (1953) regard it as Oligocene. Even at the latter younger age, *Wynyardia* is still Australia's earliest known marsupial.

3. *The Fossil.*—When visiting Hobart in 1954, the writer examined the bones of *Wynyardia bassiana* at the Tasmanian Museum, this being made possible by the kind co-operation of the Director, Dr. W. Bryden, and the Honorary Palaeontologist, M. R. Banks. The original position of the bones in the *Turritella* limestone can be seen in Plate 50A of David and Browne (1950). Most of the bones were freed from the matrix for the original study of *Wynyardia*, and the remaining ones have now been extracted by Mr. Banks. The bones were so solidly embedded that they gave no hint of being anything but *in situ*. The following list of skeletal remains was made:—

Imperfect cranium.
Ramus of mandible (no teeth; pathological malformation).
Two pieces of the pelvic girdle.
Six imperfect long bones or pieces thereof.
Thirteen vertebrae or pieces thereof.
Ten ribs or pieces thereof.
Thirty-three small fragments.

This makes a total of 66 pieces of skeleton. In the National Museum of Victoria is a rib collected by F. A. Cudmore many years ago from the same bed at the same site which could be

part of the same skeleton. It was collected *in situ* from the "upper bed", and so if established will constitute evidence to be taken with other facts to indicate that the skeleton of *Wynyardia* was really in place in the cliff.

4. *Ecological Observations.*—*Wynyardia bassiana* is a land animal found in a marine bed, and the examination of the bones preserved throws some light on how it came to be where it was found.

(*a*) No bone shows any appreciable wear. The neural spines and transverse processes of the vertebrae, although so strongly projecting, and in certain cases quite thin, show no sign of abrasion as distinct from fracture or solution.

(*b*) The bones are of such dissimilar sizes, shapes, and weights that if they were merely sedimentary materials, they could only appear in quite unsorted sediments, whereas in fact they occur in well-sorted sediments. The size and weight of the bones make them quite out of character with the fine sediments in which they were found and so cannot be considered as moved into place by water movements and deposited as sediments.

(*c*) A cast of *Wynyardia* in its original position in the matrix as well as the photo referred to above, show that the bones were not lying haphazard on the sea-floor, but were to a certain extent in their positions of articulation. The vertebral column was largely in place, the cranium was at one end of the column, and the pelvic bones with some leg bones at the other. The bones obviously arrived together and not in a disarticulated condition. *Wynyardia* must therefore have floated as a carcase to more or less the position where it was found. It would be brought by the flow of a river and probably also marine currents. The wind could affect a floating object such as this. The presence of leaves, wood, and resin in these beds, as well as the possum, suggest that a river debouched nearby. If this skeleton had floated into this area when the *Crassatella* bed was being laid down, it would surely have been destroyed in the rather turbulent waters. It would certainly have been scattered. In the quiet waters of the *Turritella* bed environment, the carcase sank to the sea floor, and bones lay little disturbed until covered by sediment (*cf.* Wintle, 1886, p. 45).

(*d*) An examination of the cast of *Wynyardia in situ* shows that the dorsal surface of the cranium was buried in the limestone, with the result that the palate was exposed to the attack

of the sea when the block in which it was held fell to the shore platform at Fossil Bluff (see Pl. 2, figs. 1-3). It is probable that there were teeth present when the fossil was first exposed to marine attack, but that they were knocked out and the palate eroded. Since *Wynyardia* arrived as a complete carcase, it would be very strange if it had no teeth. Likewise the ramus was in such a position that the sea could remove any teeth that were present. There is no reason for considering that the animal may have been edentulous because no teeth are preserved. In any case " the broken alveolar cavity for the roots of the third molar is clearly retained " (Wood Jones, 1930, p. 108).

(*e*) The mandibular ramus of *Wynyardia bassiana* has a curious structure in the region of the second molar tooth which Wood Jones has interpreted as a pathological one, the most probable diagnosis being an alveolar abscess cavity. In spite of this the animal reached maturity, but there is no doubt that the disability (however the malformation be interpreted) would affect its nutrition. It was probably swept out to sea where it found its way into quiet waters away from the turbulence of the open sea. It sank to the bottom, settling into a soft limey mud where a colony of gasteropods (*Turritella*) thrived, and in time was naturally interred. The marine muds preserved the bones for some 40 or 50 million years until marine erosion at Fossil Bluff at the end of the nineteenth century A.D. brought this interesting fossil to light.

(*f*) Many Tertiary limestones in S.-E. Australia have a vertical cleavage so that large pieces flake off coastal cliffs formed of these rocks. Such a block, containing the bones of *Wynyardia*, fell from the sea cliff at Fossil Bluff on to the hard shore platform of Permian tillite (Plate 2, fig. 3). The sea beats directly against the cliff, and so the block was immediately attacked by the sea. *Wynyardia* was thus found *in situ* in the *Turritella* limestone, but not *in situ* in the cliff. On account of the uncertainties that can attend any such occurrence, and because of the close similarity between *Wynyardia* and living possums, some workers doubted whether *Wynyardia* was as old as the rock in which it was found. One suggestion was that a possum may have fallen down a crevice where its bones were covered with rock waste from the limestone which became cemented by solutions of calcium carbonate. To determine whether *Wynyardia* was in fact as old as the *Turritella* limestone, the fluorine test was applied (Gill (1954D). Mr. W. R. Jewell, Chief Government Chemist, and his staff at the State

Laboratories, Melbourne, kindly carried out the fluorine and phosphate analyses with the following results:—

Specimen.	Percentage F.	Percentage P_2O_5.	Fluorine Index.*
1. *Wynyardia bassiana* Spencer 1900. Portion of a rib	3·10	30·0	10·3
2. Ditto	3·05	31·6	9·7
3. Ditto	3·05	31·2	9·8
4. *Wynyardia bassiana.* Portion of a vertebra	3·05	30·9	9·9
5. Fragments of whale bone	2·85	29·9	9·5
6. Tooth of Hybodontoid shark *Strophodus* (= *Asteracanthus*) *eocenicus* Tate 1894 from "*Turritella* bed"	2·80	33·1	8·5
7. Ditto. Tooth from the "Crassatella bed"	2·85	34·0	8·4
8. Fish vertebra (somewhat silicified) from the "Turritella bed"	2·10	25·5	8·2

* The fluorine index is $\frac{\%F \times 100}{\%P_2O_5}$.

The fluorine percentages are rounded off to the nearest 0·05 as the figures are considered significant to this amount. The first five specimens in the above list of analyses were kindly provided by the Tasmanian Museum, while the remainder came from the National Museum of Victoria (F. A. Cudmore Collection). Typical *Turritella* bed matrix was removed from specimen 6, and this has been preserved.

The results of the fluorine test may be summarized thus:—

Wynyardia bassiana ..	Fluorine index	9·9	(average)
Whale bone	,,	,,	9·5
Shark's tooth (upper bed)	,,	,,	8·5
Shark's tooth (lower bed)	,,	,,	8·4
Silicified fish vertebra ..	,,	,,	8·2

The *Wynyardia* and whale indices, both established on skeletal bones (see Gill, 1955, concerning the importance of this), are closely comparable. The teeth, being less permeable, have a lower index, as is to be expected. The small difference between the index of a tooth from the lower bed, and that of a tooth of the same species from the upper bed, may be taken as additional evidence that there is no stratigraphical break in the Fossil Bluff strata. They belong to the one cycle of sedimentation. The lower

index of the fish vertebra is understandable in view of its silicification. This mineralization may have its origin in solutions from the decomposing basalt above.

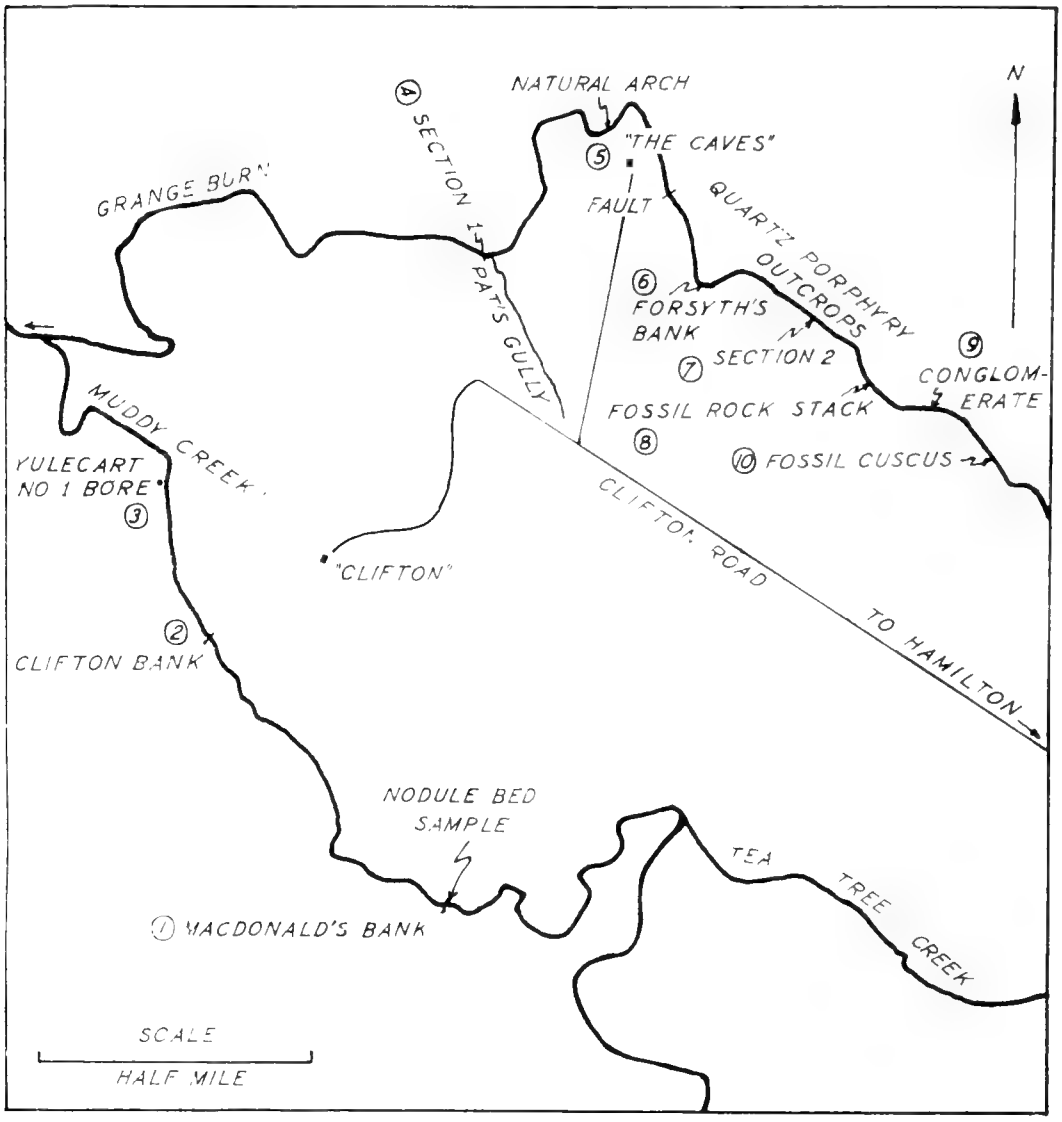
Wynyardia is a *Trichosurus* type possum, and a control for the fluorine test is provided by the analysis of a piece of the anterior end of the mandible of a present-day *Trichosurus vulpecula* from Wynyard. The contrasting figures are as follows:—

Animal.	% F.	% P_2O_5.	Fluorine Index.
1. *Wynyardia bassiana* (Tertiary). Average	3·06	30·9	9·9
2. *Trichosurus vulpecula* (Extant) ..	0·005	25·1	0·02

Wynyardia therefore has a fluorine index nearly 500 times as great as that of a possum living in the same area in modern times. Fossil bones with fluorine indices comparable with that of *Wynyardia* are found in the Tertiary beds of the Beaumaris and Hamilton districts of Victoria (Gill, 1953A, B, 1955). Thus the fluorine test, with the other evidence outlined earlier in this paper, proves that *Wynyardia* is a valid fossil having the same age as the *Turritella* bed in which it was found.

B. Occurrence of Tertiary Marsupials at Hamilton, Victoria.

1. *Grange Burn.*—The geology of the Hamilton area was first described nearly 100 years ago by Bonwick (1858), but he made no mention of the Tertiary fossiliferous beds, so probably they had not been discovered then. Descriptions of Tertiary fossils from the Hamilton district appeared in the 1860's, and the localities on Muddy Creek, Violet Creek, and Grange Burn have become classic for Tertiary studies in Victoria. The references in literature are far too numerous to warrant being listed here, but the principal discoveries are recorded in Ashby and Cotton (1939), Chapman (1914, 1916, 1923), Chapman and Cudmore (1924, 1934), Colliver (1933), Crespin (1936), David and Browne (1950), Dennant (1889), Duncan (1865, 1875, 1876), Gill (1952, 1953A, B), Howchin (1889, 1890, 1891), Parr (1926, 1939), Withers (1953).



TEXT-FIGURE 3.—Locality map of the area west of Hamilton, Victoria. Numbers in circles are localities so numbered in the text. Locality 11 (diatomite and polleniferous clay) is on Grange Burn 1⅛ mile east of the edge of the map.

In Victoria there are three Tertiary sedimentary basins of different sizes, viz., the Portland-Mt. Gambier 2-lobed sunkland in the west, the Port Phillip sunkland in the central area, and the Gippsland sunkland in the east. Peripheral to these basins are thin shelf deposits. Most of the type sections for the various Tertiary stages established in Victoria are in the thin shelf deposits. There have not been the orogenic movements to cause exposure of great thicknesses of Tertiary rocks such as can be seen in New Zealand. The Tertiary beds at Hamilton are thin shelf deposits. Boutakoff and Sprigg (1953) have listed two

formations which they name "Muddy Creek" (Miocene) and "Grange Burn" (Lower Pliocene). As a number of observers have noted in the past (e.g. Chapman, 1914), there are actually three formations in this area, viz.:—

Youngest Grange Burn Coquina.
Muddy Creek Marl.
Oldest Bochara Limestone (here named after the Parish of Bochara).

Boutakoff and Sprigg merge the two older formations, but the writer finds that these three lithological units can be mapped in the field with facility, and so prefers the traditional division into three formations. Singleton (1941) outlines the history of the controversy concerning the order of succession of these three formations, a question settled ultimately by the Yulecart No. 1 bore. However, the writer has found that the three formations outcrop in one section (marked section 1 in text-fig. 3) on the south bank of Grange Burn at Pat's Gully (see text-fig. 4). Auger holes were put down to remove any possible doubt concerning the relationships of the highest formation, which is largely covered with soil and grass, although the typical fossils are abundant therein. Auger Hole 1 on the section line 3 feet north of the fence penetrated:—

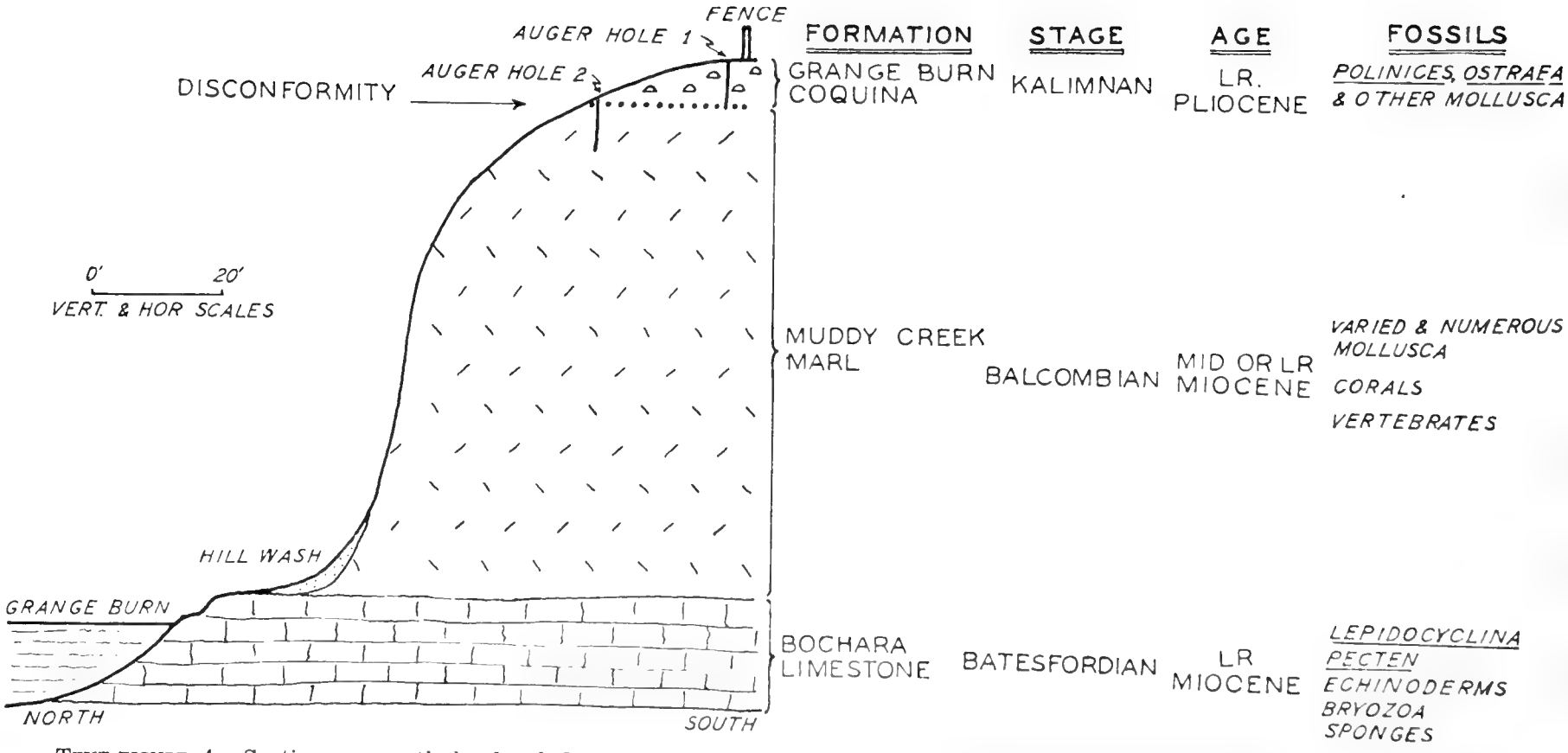
0 in. to 9 ins.—Dark chocolate soil with basalt boulders and small limestone nodules.

9 ins. to 6 ft. 9 ins.—Fawn earthy limestone or calcareous sand. At 1 ft. 3 ins. band of *Polinices* in hard crystalline limestone. Limey at 32 ins. (Pedological effect), and at 3 ft. 3 ins. a thin hard band below which were numerous limestone nodules. Fossils, including *Polinices*. At 5 ft. 6 ins. to 5 ft. 9 ins. large subspherical limestone nodules of varying sizes but commonly 4 to 5 cm. in diameter and consisting of fine well-rounded quartz sand with some mica, lithified by a calcareous cement. Another *Polinices* horizon at 5 ft. 10 ins. Numerous nodules of different kinds at junction with underlying marl bed.

6 ft. 9 ins.—Grey clayey marl (Balcombian).

Auger Hole 2 on the section line 23 feet north of fence penetrated:—

0 in. to 10 ins.—Dark chocolate soil with pieces of limestone, nodules, and shells of *Polinices, Ostrea, &c.* (Kalimnan). The nodules are like those at 5 ft. 6 ins.



TEXT-FIGURE 4.—Section on south bank of Grange Burn at Pat's Gully (loc. 4 on map) showing succession of Tertiary formations. Here proposed as type section for the three formations appearing therein.

to 5 ft. 9 ins. in Auger Hole 1 but smaller. On digestion in acid there was a similar residue of fine well-rounded quartz and some mica, but there was also an appreciable amount of carbonaceous matter.

10 ins. to 6 ft. 8 ins.—Fawn earthy clayey limestone. Free lime at 32 ins. a little more clayey at 3 ft. 3 ins., firmer and greyer (especially inside lumps) at 4 ft. 2 ins., *Corbula* at 4 ft. 6 ins. and further fossils at 5 ft. 6 ins., iron enrichment at 5 ft. 8 ins., and typical Balcombian marl at 6 ft. 8 ins.

6 ft. 8 ins. to 7 ft. 8 ins.—Marl.

This auger hole log may be summarized thus:—

0 in. to 10 ins.—Soil and Kalimnan fossils.

10 ins. to 6 ft. 8 ins.—Weathered Balcombian marl.

6 ft. 8 ins. to 7 ft. 8 ins.—Fresh (although still somewhat oxidized) Balcombian marl.

In the section at Pat's Gully the outcrops of the three formations are rich in fossils.

As far as outcrops indicate, the basement rock in this area is quartz porphyry (see text-fig. 3). No laboratory determinations of the rocks have been made, the names given being field ones only. The Bochara Limestone (lowest of the three Tertiary formations) is highly calcareous and is lithified so as to be crystalline in part. The strata are horizontal or with low dips. They constitute the creek cliff at Henty's (loc. 5) where they have a slight westerly dip. A short distance east of Henty's they abut against the Muddy Creek Marl, the junction consisting of a reversed fault (see text-figure 3) with a throw of the order of 100 feet. This is the largest fault noted in the area studied. The marl appears to have been pulled up a little by the fault so that it has a slight easterly dip. Near the end of Clifton-road, cliffs expose about 50 feet of Bochara Limestone, but that the formation is thicker than this is proved by the Yulecart No. 1 bore (Mines Dept., 1938). The fossils indicate a marine environment of warm clear water.

The boundary between the Bochara Limestone and the overlying Muddy Creek Marl is a sharp and conformable one. Many springs emerge along this contact. The Bochara Limestone can be followed on Grange Burn in its more or less westerly dip from Henty's, and as the Muddy Creek Marl appears in the creek

walls, the vertical cliffs caused by the Bochara Limestone give way to the sloping banks caused by the marl. This difference in lithology is the origin of the terraces downstream from Henty's which Chapman (1914, fig. 16) interpreted as due to a rejuvenation of the stream. This formation is unlithified and so the name " marl " rather than " marlstone " is applied to it. The formation is very consistent in character throughout the outcrops of the area. Quiet waters of moderate depth are indicated. There is a remarkably rich fauna containing over 400 species of described mollusca alone. Lepidocyclines still occur but not in the rock-forming quantities found in the Bochara Limestone. There is evidence of decreasing temperature through the three formations from below up, but the climate at the end of that period of time was still warmer than the present. This decrease in temperature through the Miocene and Pliocene was apparently worldwide, and recently Emiliani (1954) has traced it by the oxygen isotope method of palaeotemperature measurement.

Disconformity.—Of stratigraphical importance is the disconformity between the Muddy Creek Marl and the Grange Burn Coquina, marked by a nodule bed. There is room for difference of opinion on what to call the Grange Burn formation. On Muddy Creek it consists of a shell bed only, while on Grange Burn the same shell bed occurs but over it is a sandy limestone which is generally highly fossiliferous too. The shells are both whole and broken. The term " Coquina " as used by Rodgers (1954) appears to the writer to be the best term to use.

For the study of this disconformity, a site was selected at MacDonald's Bank on Muddy Creek where the nodule bed is clearly developed, and a portion of it 24 ins. long, by 4 ins. wide, by 2 ins. thick vertically was excavated. Every nodule 5 mm. or more in diameter was collected. A total of 208 nodules was obtained including a large piece of whalebone which overlapped the boundaries of the area given. The nodules comprised:—

1 subrectangular piece of dark-brown mineralized whalebone with rounded edges and a bright surface glaze. It measures 20 cm. by 5 cm. by 2 cm. approximately.

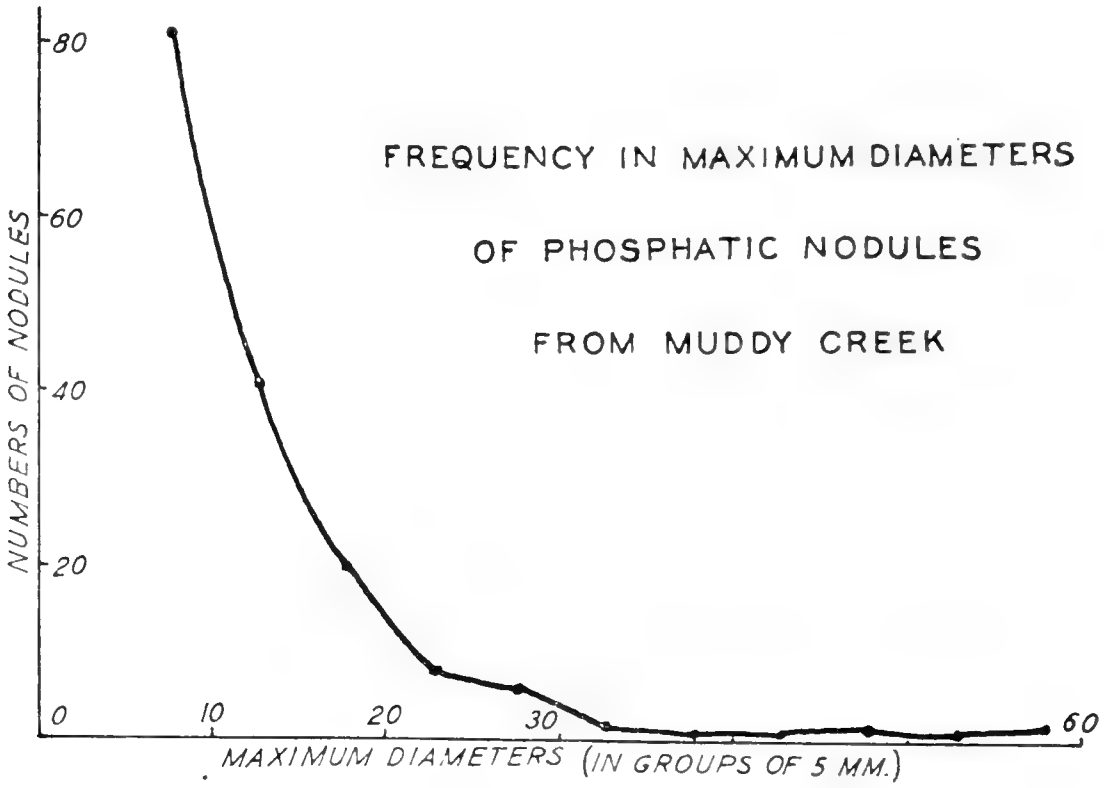
41 waterworn fossil fragments—pieces of molluse shells, cidaroid spines, bryozoa and bone varying in size and in degree of mineralization. One shell fragment 19 mm. by 14 mm. by 8 mm. consists of the umbonal portion of a heavy lamellibranch shell and is much bored by marine molluses.

166 phosphatic nodules consisting chiefly of pieces of fossiliferous marlstone indurated in varying degrees with phosphate and iron oxide; some contain glauconite. Mr. G. Baker kindly demonstrated the phosphatic nature of these nodules. All are well rounded, and most of them possess a moderate sphericity, but some are flattish and some sub-cylindrical. Some have encrusting bryozoa and some show evidence of boring. A few nodules have been broken and then rounded on the edges and glazed. One contains a nodule formed at an earlier time. The glaze or polish on the nodules does not penetrate steep-sided depressions and so has apparently been induced by surface friction and is not a chemical precipitate, or not entirely so. A size analysis based on maximum diameters showed the following distribution of sizes among the 166 phosphatic nodules:—

5 mm. to 9 mm.	inclusive . .	81	nodules
10 mm. to 14 mm.	„ . .	41	„
15 mm. to 19 mm.	„ . .	20	„
20 mm. to 24 mm.	„ . .	8	„
25 mm. to 29 mm.	„ . .	6	„
30 mm. to 34 mm.	„ . .	2	„
35 mm. to 39 mm.	„ . .	1	„
40 mm. to 44 mm.	„ . .	1	„
45 mm. to 49 mm.	„ . .	2	„
50 mm. to 54 mm.	„ . .	1	„
55 mm. to 59 mm.	„ . .	2	„
80 mm. to 84 mm.	„ . .	1	„
		166	

In the first seven categories (i.e. apart from the seven extra large ones at the end of the list), each group numbers about half the preceding one, viz. approximately 80, 40, 20, 10, 5, 2, 1. These nodules thus present in their sizes as measured by their maximum diameters a simple geometrical progression. This is shown graphically in text-fig. 5. Some of the smaller nodules superficially look rather like buckshot gravel, which is a pedological product and would indicate derivation from a land surface (Gill, 1953F). However, on grinding a surface on some of these it was found that they generally consist basically of bryozoa; they are as phosphatic as the rest.

Phosphatic nodules are found on the floors of present seas. Sverdrup, Johnson, and Fleming (1942) write, " In certain near-shore localities phosphorite $Ca_3(PO_4)_2$ forms a cementing material which accumulates in nodules and crusts. These phosphate nodules were first discovered by the *Challenger* off the Cape of Good Hope . . . Phosphorite is commonly associated with abundant calcareous remains and glauconite. Pelagic foraminifera and benthic remains may be found, and also the teeth and bones of fish and marine mammals.. The phosphorite nodules have a characteristic smoothly rounded surface with the upper surface having a glazed unweathered appearance." (pp. 1032-1033.)



TEXT-FIGURE 5.

All the smaller phosphatic nodules of the Hamilton district are glazed but not all the big ones. When glazed, they are glazed all over and not just on the upper surface. They vary from light to dark brown in colour. Some are greenish due to the presence of glauconite. Of the seventeen ground to show their internal structure, one was oolitic and the rest massive. They generally consist of marl cemented together with the phosphatic mineral. Two of the nodules had cavities containing uncemented marl.

Twenhofel (1950) discusses the various theories advanced to explain the origin of phosphatic nodules, and concludes, " The

deposits were formed in place, they are in places where clastic sediments are not accumulating, and they are not erosion remnants ". At Hamilton the geological evidence shows that:—

1. The nodules probably formed in place because they cannot be satisfactorily accounted for as sedimentary materials. Terrigenous material is rare.

2. The time was one of non-deposition because the formation underneath is Balcombian and the one above Kalimnan with the Cheltenhamian (Upper Miocene) unrepresented.

3. The sea was not of great depth as is shown by the fossils. The sediments are shelf deposits, and they are glauconitic.

4. Conditions of chemical reduction obtained on the sea floor to form the glauconite, and the seas were probably alkaline (*cf.* Twenhofel, 1950). " Rich glauconite occurrences lie adjacent to land areas where plutonic and metamorphic rooks are exposed." Quartz porphyry outcrops frequently in the Hamilton area.

In order to test the fairness of the sample of nodules described above, excavations were made at various places on both sides of Muddy Creek. It was found that the nodules collected were typical, although in some places there was a higher proportion of elongate or cylindrical ones. Internal casts of a lamellibranch and two gasteropods were noted in the same phosphatic and ferruginous material; they likewise had rounded edges and were glazed. In places the nodule bed fades out. In Muddy Creek the bed has a dip of approximately 1° upstream.

The largest nodule I have seen was collected by Dr. G. B. Pritchard from Grange Burn. It is of marly sediments about 7 inches long by 3 inches in diameter, cylindrical in general shape but slightly arcuate. It is pierced by numerous pholad burrows, commonly ¼ inch in diameter. In some cases fossil pholads still exist in the fossil burrows which have been infilled later with sediment. There are other smaller holes cut (see Turner, 1953) by boring molluscs. The nodule is highly phosphatic. Some nodules have epiphytic growths on them, such as one collected by W. J. Parr on which are numerous small corals. Phosphatic nodule beds have been described elsewhere in Victoria in the Geelong district (Coulson, 1932; Keble, 1932), at Beaumaris (Singleton, 1941), and near Princetown (Baker, 1945).

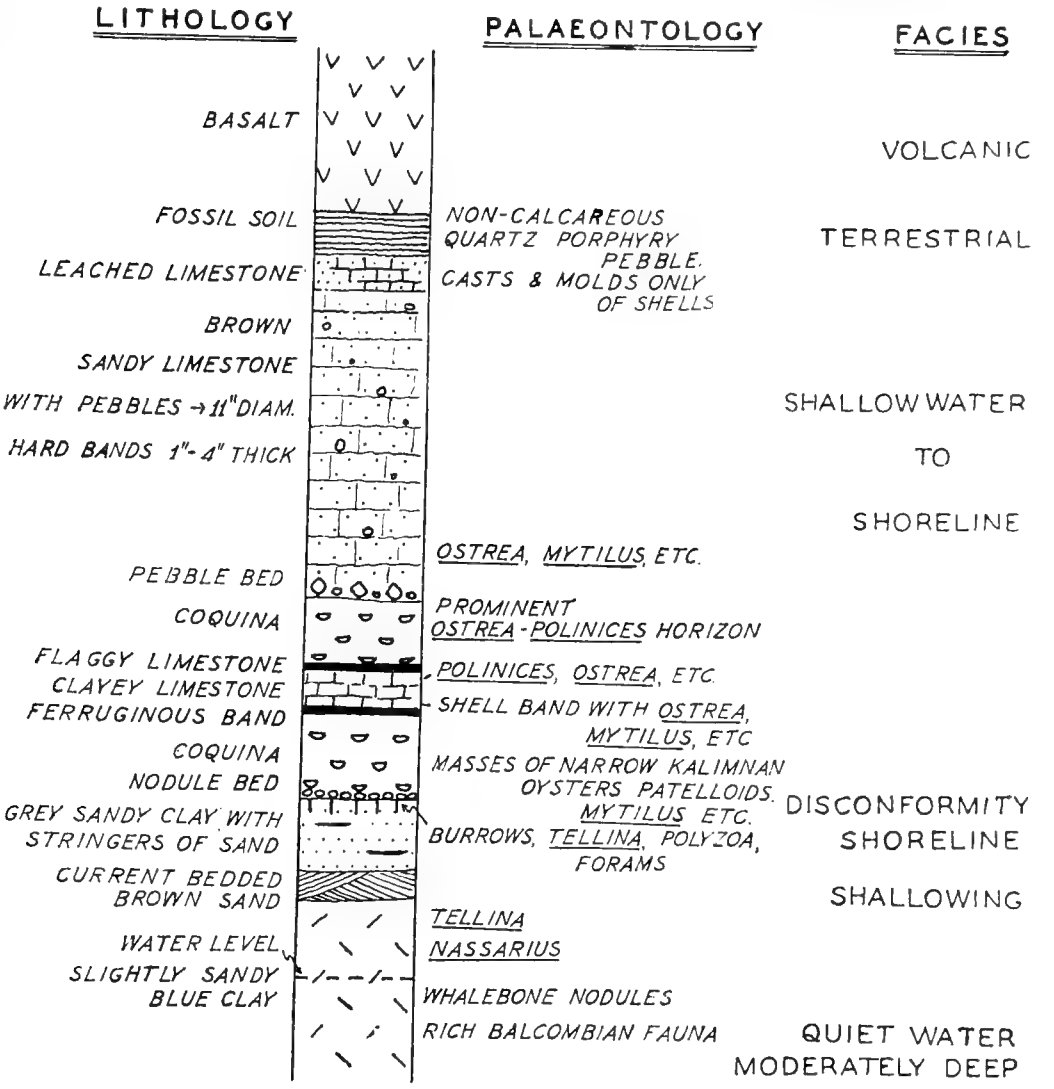
It is interesting to compare the Hamilton nodules with the authigenic phosphorite nodules described from off the Californian coast by Emery, Butcher, Gould, and Shepard (1952). Over 90 per cent. of the samples came from a submarine bank and much of the phosphorite was " nodular and polished as though in the process of formation ". " Broken and re-cemented pieces occur occasionally and several nodular specimens include pebbles of clastic material." Borings in the phosphorite are filled with recent sediments. These nodules are Quaternary in age but formed before the last glacial stage. Emery and Dietz (1950) have described phosphorite of Miocene age in North America, and Willcox (1953) has given an account of phosphatic beds in England. Both writers comment on the mode of formation of such deposits.

The nodule bed of the Hamilton district contains a large number of vertebrate fossils, including whales, sharks, and fish (represented by jaws, palates, and vertebrae). Stratigraphically, the nodule bed is Kalimnan in age, because although it rests on a formation of Balcombian age, it is itself part of the overlying Kalimnan formation. When the sample nodules were being extracted as described above, such typical Kalimnan mollusca as *Polinices cunninghamensis*, *Nassarius crassigranosus*, *Zenatiopsis angustata*, and *Glycymeris decurrens* were noted in between the nodules. However, a cast of *Aturia australis* (a Cheltenhamian or Balcombian fossil) was found in the nodule bed by Dr. G. B. Pritchard (Nat. Mus. Coll.).

In the National Museum there is a collection of 49 species of Kalimnan fossils and a highly phosphatic nodule from Goodwood station near Minhamite Railway Station 25 miles S.-E. of Hamilton (see text-fig. 1) proving the extension of the Pliocene beds some distance further south. There is also a small collection of Kalimnan fossils from a well at 170 feet at Goroke, 75 miles N.-N.-W. of Hamilton (pres. by Mrs. Ellen M. Harvey, 13.9.23).

The late Mr. W. J. Parr kindly drew the attention of the writer to the fact that the 1946 floods had washed out a section of Grange Burn, revealing the Tertiary beds further upstream than previously. Section 2 (text-fig. 6) was measured in November, 1950 on the south bank of Grange Burn at the site marked on the map (text-fig. 3). It will be seen from this section that below the nodule bed there is a zone with current-bedded sands and sandy lenticles in a clay bed. These structures suggest a shallowing sea. Quiet waters in which clay settled are replaced by disturbed waters with movement enough to transport sand and induce current-bedding in it. In this area the level of the nodule

bed was surveyed over as great a distance as possible, and the average dip was found to be 0° 22″ downstream. This slight dip is shared by the beds above and below it as can be seen by their relation to the water level as one moves along Grange Burn.



TEXT-FIGURE 6.—Section No. 2 on Grange Burn, near Hamilton, Victoria. From water level to the base of the basalt is 21 ft. 6 in.

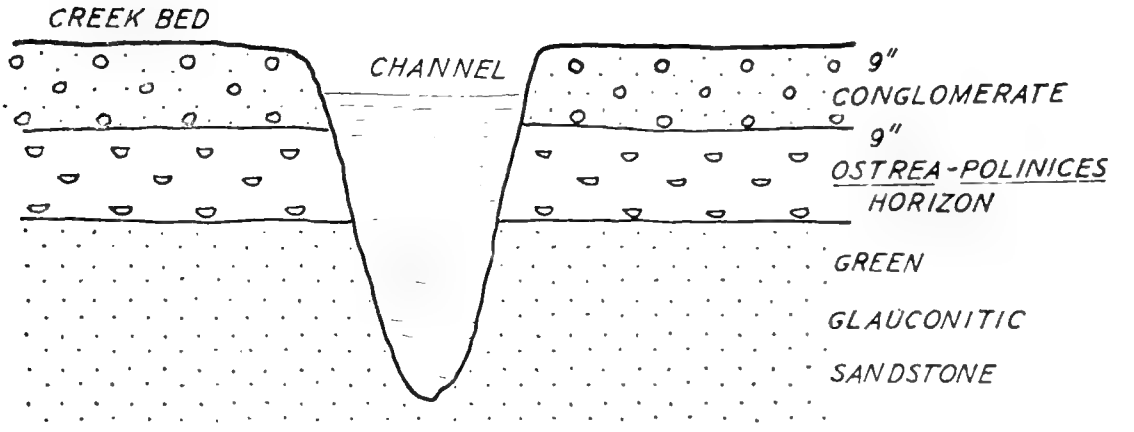
About 275 feet east of section 2, a richly fossiliferous band outcrops in the creek bed with typical Balcombian fossils. On top of this, especially in the south bank, is a " nodule bed " of waterworn and glazed fragments of whale skeleton up to 1 foot long. Locally at least there are thus two nodule beds about 5 feet apart stratigraphically. No pieces of whale bone were found in the higher nodule bed in this vicinity, but if the underlying 5 feet of rock

had been eroded bringing the two nodule beds together, we would have the typical nodule bed of other localities. In the Muddy Creek section there does not appear to be any deposit which can be equated with this 5 feet which could be regarded as a " zone of disconformity ". From the Balcombian marl one passes directly to the nodule bed and so the overlying Kalimnan as shown in text-fig. 10. The same applies to section 1 on Grange Burn.

Grange Burn Coquina.—This formation is extremely rich in shells both complete and broken, and many of them still retain much of their natural colour. On Muddy Creek the formation consists of the well-known shell-bed at MacDonald's Bank, but a greater thickness occurs along Grange Burn. The fauna consists of over 150 species of described mollusca alone, of which something like 10 per cent. are still living. The fauna is a shallow-water marine one, including molluscs such as patelloids, *Mytilus*, and borers. Parr (1941) has drawn attention to the presence of shallow water foraminifera in this formation.

There are extensive outcrops of quartz porphyry on Grange Burn opposite section 2. At locality 8 (see map, text-fig. 3) the creek flows over a small saddle in the quartz porphyry which separates the main mass from a fossil rock stack. No Balcombian beds were found outcropping upstream from this little waterfall, but there are Kalimnan beds of near-shore facies. About 130 yards upstream from locality eight and on the north bank there is quartz porphyry with holes infilled with ferruginous and fossiliferous conglomerate (loc. 9. See Pl. 4, fig. 3.). Near the porphyry the conglomerate is very heavy with boulders as much as 15 inches in diameter but generally less. Further away the conglomerate is not so heavy. The conglomerate is very poorly sorted with all grades of material. The contained pebbles are mostly porphyry but there are some of the greensand on which the conglomerate rests, showing penecontemporaneous erosion. The material of fine conglomerate size is commonly of milky quartz, while the sand fraction is chiefly clear and milky quartz and calcareous matter. The fossils are oysters (which are numerous), calcareous worm tubes, and gasteropods.

A typical section in the north bank of Grange Burn between localities 8 and 9 shows 4 ft. 6 ins. of current-bedded calcareous marine sandstone resting on 2 feet of conglomerate. The floor of the creek here consists of this conglomerate but the corrosion of channels reveals that the succession is as shown in text-fig. 7. Mr. G. Baker kindly confirmed that the greensand is glauconitic. Where oxidized, it assumes a fawn colour.



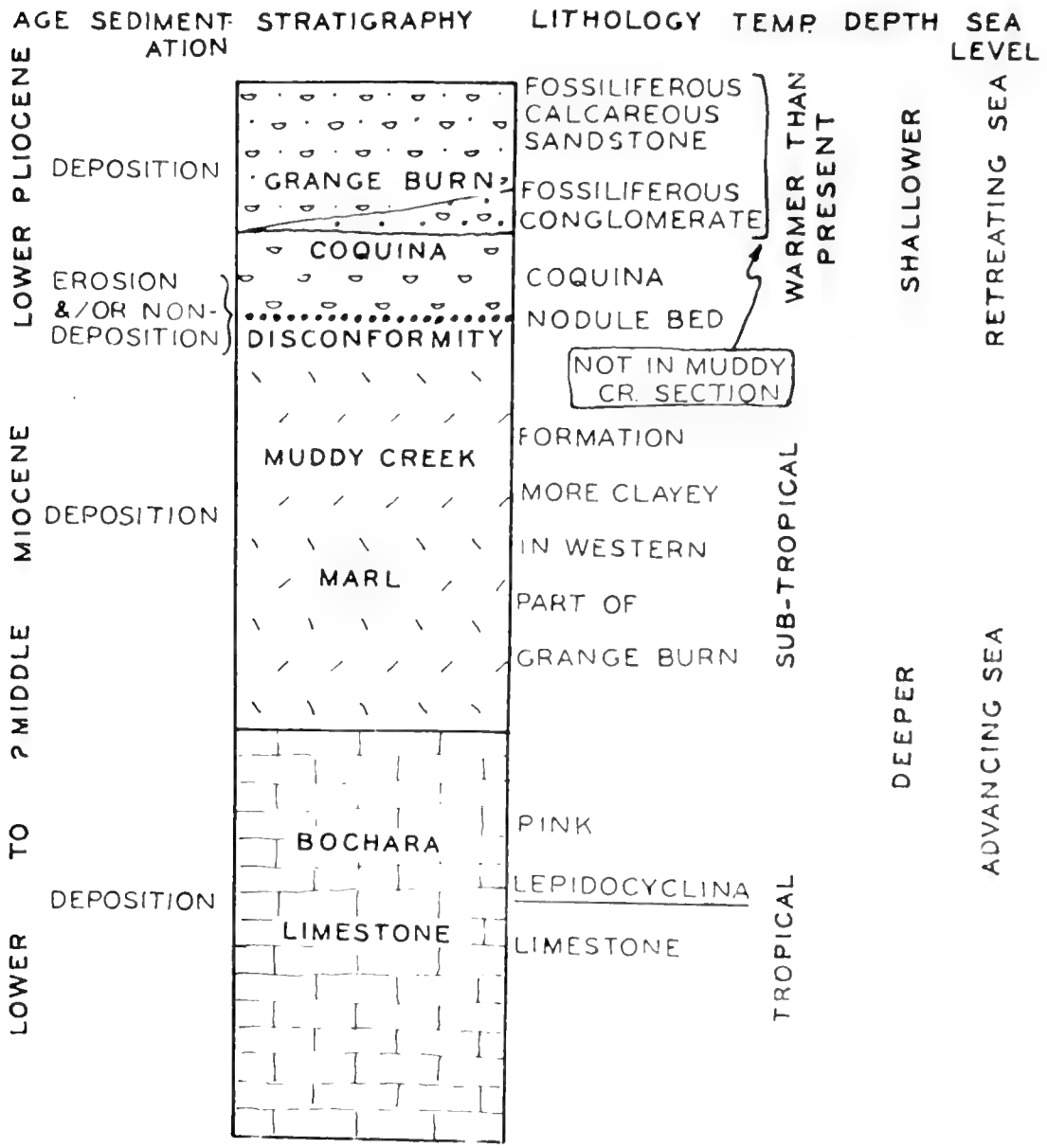
TEXT-FIGURE 7.—Section on Grange Burn, near Hamilton, between localities 8 and 9.

Summary of marine facies.—The geology and palaeontology done in this area are only a fraction of what remains to be done, but sufficient examination of the rocks has been made to understand the succession and the general facies of the various formations. This information is summarized in text-fig. 8. The lowering of temperature with time suggested by the fossils is to be checked by O^{16}/O^{18} analyses. The shallowing of the sea is evident from the development of conglomerate, current-bedding, glauconite, and shoreline forms of life. This disconformity between the Muddy Creek Marl and the Grange Burn Coquina is a sedimentary break representing upper Miocene time, more or less.

Ecologically, it is not likely that any bones of terrestrial animals would be found in the Muddy Creek Marl, but it is more likely in the near-shore to shoreline beds of the Grange Burn Coquina. As already stated, a piece of kangaroo jaw was found in this formation at Forsyth's Bank (Colliver, 1933; Singleton, 1935; Gill, 1953A, B; 1955).

Terrestrial Facies.—At locality ten (see map, text-fig. 3) on Grange Burn there is a fossil "podsol" soil with calcareous nodules underneath the basalt which blankets all the Tertiary beds described from the Hamilton district. In this soil are the roots of trees in position of growth (Pl. 4, fig. 1), and casts of branches have been found in the basalt. All the woods seen were softwoods. One sample was identified as probably *Phyllocladus* by W. D. Ingle of Forest Products Division of C.S.I.R.O. The two largest trees noted were those having root complexes 20 ins. wide by 6 ins. thick, and 17 ins. by 4 ins. The largest single root measured had a diameter of 7 ins. in one direction by 4 ins. at right angles to the first diameter. The wood has been coalified in some places,

the water probably having been expelled by the pressure and heat of the basalt above. Baker (1950) also noted this wood. Mr. J. H. Willis has informed me that he found a log of *Phyllocladus* in Grange Burn about a foot in diameter and 5 to 6 feet long.



TEXT-FIGURE 8.—Stratigraphy of the area west of Hamilton, Victoria.

There is a good deal of carbonaceous matter in lenticles under the basalt. Some of this was examined for pollen by Dr. Isabel Cookson. No pollen was found but the material contained plentiful plant fragments.

Lacustrine facies.—Further upstream at locality eleven (see map, text-fig. 3) there is a diatomite under the basalt, i.e. in the same stratigraphic position as the soil with *Cuscus* and *Phyllocladus*. The diatomite is underlain by a grey clay which merges into a black clay containing plentiful pollen spores and fossil leaves (for section see Gill, 1953b). The following diatoms have been recognized in the diatomite (Tindale, 1953; Gill, 1953b).

Cocconeis placentula.
Cymbella gastroides.
Epithemia zebra.
Eunotia lunaris.
E. pectinalis.
Gomphonema intricata.
Melosira crenulata
M. granulata.
Navicula viridis.
Stauroneis anceps.
S. phoenicenteron.
Surirella fragments.

The above is a freshwater flora. *Cymbella* is an exclusively freshwater genus (Taylor, 1929).

In the carbonaceous clay under the diatomite *Acacia*-like phyllodes have been recognized (Cookson, 1954). Dr. I. Cookson, Dr. S. L. Duigan, and Miss K. M. Pike have recognized the following flora from pollen grains and spores:—

Acacia myriosporites.
A. octosporites.
Araucariacites australis.
Casuarinidites cainozoicus.
Dacrycarpites australiensis.
Dacrydiumites florinii.
Gleichenia circinidites and other fern spores.
Haloragicidites haloragoides.
Myrtaceidites eucalyptoides forma *convexus.*
Triorites harrisii.

Dr. Cookson writes, "There is every reason to believe that in the Hamilton and Daylesford regions a mixed conifer-*Eucalyptus* forest was not far removed from the seat of sedimentation." The conifers dominated the flora but not as completely as the eucalypts

do now. The absence of *Nothofagus* invites comment. Living species like well-drained slopes in an area of plentiful rainfall, and probably the fossil species did too. At the Yallourn brown coal open cut there is an exceptionally good opportunity of studying the flora, but most of the wood and leaves are of conifers, although *Nothofagus* pollen is common. The interpretation of this situation is that the conifers occupied the lowland areas, while *Nothofagus* clothed the slopes of the surrounding hills (Cookson, 1945). Similarly, in the Tertiary lignites at Kiandra in the Snowy Mountains area of New South Wales there is plenty of *Nothofagus* pollen, but no leaves or wood belonging to that genus were found. The leaves were of lauraceous and coniferous types and the woods were coniferous (Gill, 1954A). Again it is to be inferred that the conifers and lauraceous types lived along the waterways while *Nothofagus* grew on the hill slopes round about. Although not present at Hamilton, *Nothofagus* is plentiful in other Pliocene deposits in Victoria, and it still occurs in the mountains in suitable habitats. The reason for its absence at Hamilton may be the flatness of the terrain. There was an adequate rainfall but no well-drained slopes where it could flourish. This interpretation is supported by the absence of such detritals in the sub-basaltic deposits as one could consider to be derived from the nearby Grampian Mountains. It may well be that they were uplifted in the Upper Pliocene when the countryside was faulted and the basalts outpoured.

Apart from the absence of *Nothofagus*, the flora at Grange Burn is quite typical of the Upper Tertiary. A flora consisting of conifers plus broad-leaved types (the so-called *Cinnamomum* flora of some writers) is typical of the Tertiary in Australia, and has often been called the Miocene Flora, although Sussmilch (1937) thought its date even later. Hills (1938) gave reason to think that it extended from Oligocene to Pliocene. The writer (Gill, 1952) showed that it ranged from Palaeocene to Upper Pliocene—the whole span of Tertiary time. Fleming (1953) has hinted that the presence of *Heligmope dennanti,* a pelagic gasteropod genus found in other parts of the world too, may mean that our Kalimnan beds include more than Lower Pliocene. If this prove to be so, then the terrestrial and lacustrine subbasaltic facies in the Hamilton area are higher still in the Pliocene. On the other hand, they are definitely not Pleistocene, for none of the conifers so characteristic of the Tertiary have been found in the Pleistocene. *Cuscus* belongs to tropical Australia (Cape York Peninsula) and New Guinea, and it would be very difficult to picture this animal here in the Pleistocene.

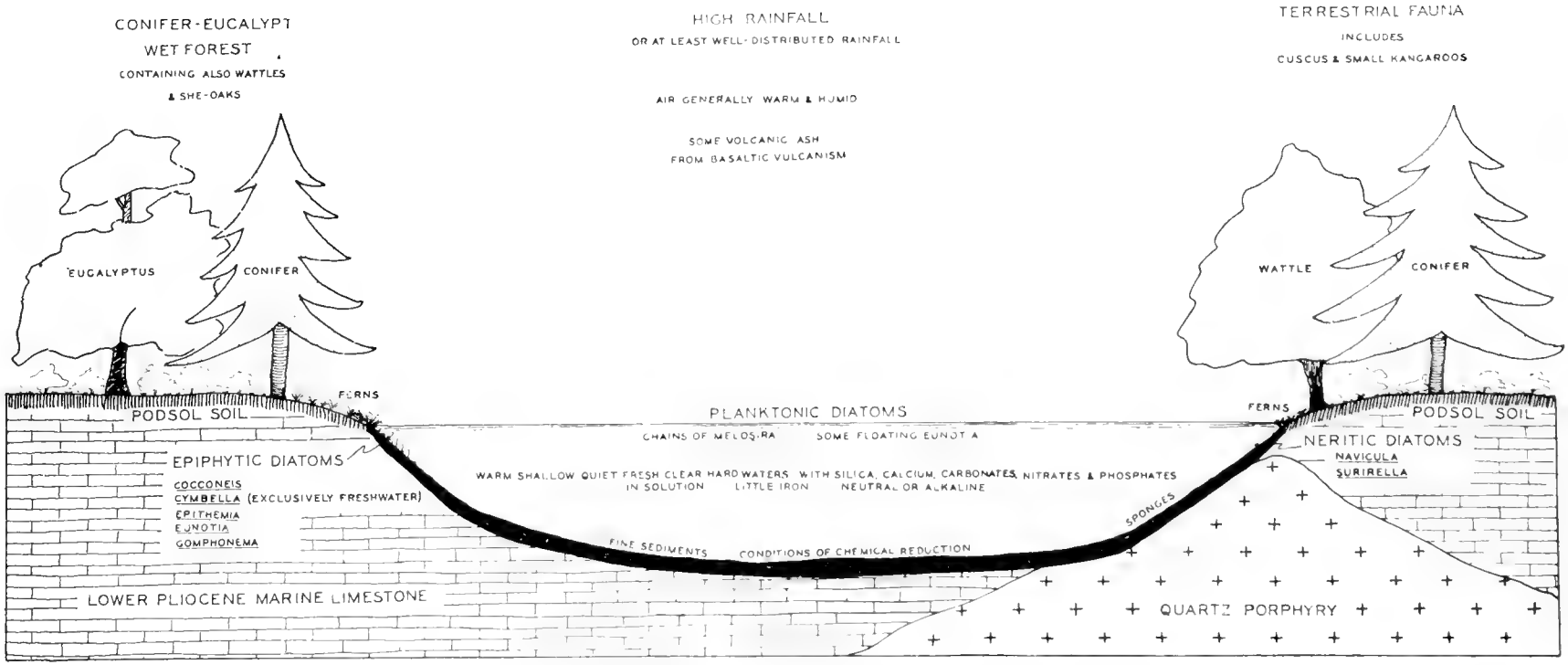
Sponge spicules are common in both the diatomite and the carbonaceous clay. Some of the carbonaceous claystone was boiled in nitric acid for two days, then washed and dried. From the remaining sediment spicules belonging to the Spongillidae were picked with a fine brush. They are of two kinds—a size such as is found in most freshwater deposits, and then an exceedingly fine and delicate type of spicule. The spicules are very numerous indeed, indicating a rich sponge fauna.

A Pliocene lacustrine deposit similar to the Hamilton one has been described from Stony Creek near Daylesford in Victoria (Orr, 1927; Coulson, 1950). Diatomite, and pollen-bearing carbonaceous clays with leaves and sponge spicules occur there.

Palaeoecology.—A reconstruction of the terrestrial and lacustrine facies of Upper Pliocene time in the Hamilton area is presented in text-fig. 9. The pluvialty and warmth of the climate are indicated by the Tertiary flora, the wealth of ferns in a flat terrain where there could be no deep fern gullies, the leached soil, the presence of lakes, and the wealth of carbonaceous matter and pollen. *Cuscus* is an inhabitant of warmer and wetter parts than the Hamilton area is now with its temperate climate and rainfall of 26·98 ins. (average of 73 years. See Hounam, 1949.) The nearest home of the cuscus is now 1,700 miles further north in the tropics. Apart from the cuscus, there is no reason to think that the climate was tropical, and probably can best be estimated to have been a warm temperate one and pluvial.

The depth and nature of the lacustrine sediments shows that the lake waters were quiet and shallow. The large quantity of vegetable matter would develop conditions of chemical reduction on the lake-floor. The wealth of diatoms and sponges indicate that silica, calcium, carbonates, and nitrates were in solution as these are necessary for their metabolism. The bedrock of highly-calcareous rocks would ensure the presence of carbonates and neutralize any acidity, so that one might expect the waters to be neutral or even on the alkaline side. Recent work shows that the alkalinity of the waters is an important factor for some diatoms at least (Knudson, 1954). The sea had recently retreated from this area but was probably at some distance when this lake was in existence because there have been found no Hystrichosphaeridеae which are so common in deposits near coasts (cf. Cookson, 1953), and no pollen of salt marsh plants such as chenopods. The flat coastal plain would provide a limited number only of biotopes.

The podsol soil has no buckshot gravel or iron pan in it, and this is due no doubt to the inhibitory effect of the highly calcareous parent material (Gill, 1953F). Iron is scarce in this environment.



TEXT-FIGURE 9. Diagram summarizing present knowledge of the terrestrial and lacustrine facies of Upper Pliocene time in the Hamilton area, Victoria. Basalt flows buried this terrain.

There are streaks of iron minerals in the fossil soil now, but these are obviously from the overlying basalt. In places there are streaks of greenish-yellow which could be nontronite, also derived from the basalt. The original soil was highly leached, being sandy (mostly clear quartz) at the old land surface (a loipon from the limestone), and with numerous calcareous nodules at 32 ins. from the surface and further down. The nodules are rounded and commonly about 4 cm. in diameter. The limestone in which the podsol is developed consists of 50 per cent. $CaCO_3$ at the subsoil level. Professor G. W. Leeper kindly described samples from the profile as follows:—

A. Very sandy loam.

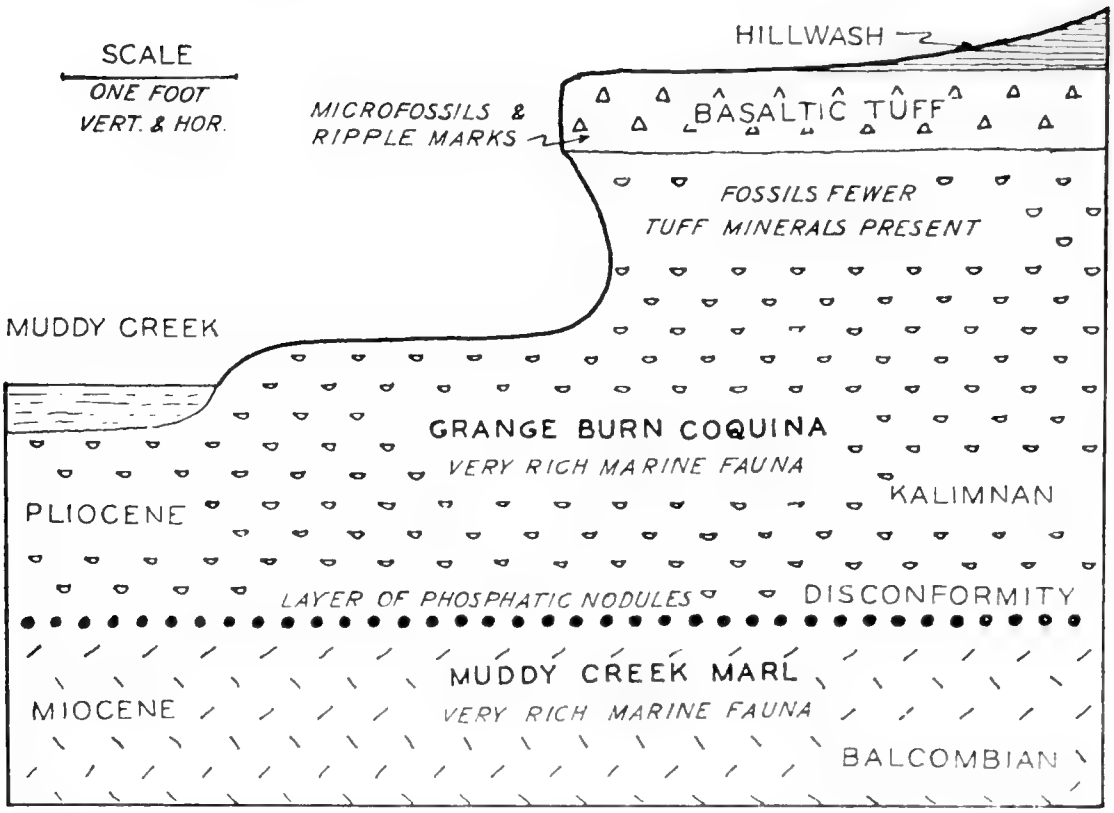
B. Sandy clay loam to clay loam, mottled, with light-coloured limey patches ¼ in. to ½ in. in diameter.

There is an enrichment in the B horizon in both clay and lime. The limestone on which this soil is developed must have been reduced in thickness by the process of soil formation.

Fragments of the carbonaceous clay from the lacustrine deposit were heated in a crucible. Upon oxidation of all the carbonaceous matter, the remaining material was rather like pottery, this texture being due to the fusion of the numerous sponge spicules. Three of the fragments were white and two a pale-fawn, illustrating the poverty of iron in this formation. If the lake waters were alkaline they would dissolve relatively little iron. " The solubility of iron at pH6 is about 10^5 times greater than at pH8·5 " (Mason, 1952, p. 140).

Terrestrial Facies in Muddy Creek Section.—On moving upstream from the Balcombian beds at Clifton Bank on Muddy Creek, one comes to MacDonald's Bank with the nodule bed forming the base of the Kalimnan deposits. The Kalimnan coquinoid here is just like that above the nodule bed at section 2 (see text-fig. 3), and many other places along Grange Burn. However, on passing further up Muddy Creek and so higher stratigraphically, instead of encountering the calcareous sandstone seen on Grange Burn, one is confronted with a light-grey basaltic tuff, as shown in text-fig. 10.

The tuff is 11 inches thick in the measured section, but is much thicker than this. On account of hillwash, there are no outcrops by which the succession can be followed up the side of the valley. The tuff is stratified and dips 1° upstream as does the nodule bed. Apparently the slight tilting of the beds took place after the tuff was deposited.



TEXT-FIGURE 10.—Section on south bank of Muddy Creek, near Hamilton, Victoria, at the east end of MacDonald's Bank (locality 1 in text-figure 3).

In the marl immediately under the tuff some volcanic minerals were found. The light minerals are fine-grained, and consist mostly of well-rounded quartz and of mica. The heavy minerals are of very small grain size, and include hackly olivine and augite. Zircon, tourmaline, chlorite, and black opaques are present. The small quantity and fineness of the basaltic tuff minerals in this bed suggest minor or distant volcanic activity. However, the stratified tuff which overlies it indicates strong volcanic activity. There are numerous marine microfossils and a few macrofossils in the lower part of this tuff, and some ripple marks, showing that the tuff was laid under water. No quartz can be seen in the tuff in hand specimen but some was found on microscopic examination. Olivine is a very common constituent.

In the National Museum there is a piece of tuff whose label reads, "Presented by Rev. Mr. McFarlane, in March, 1877. Muddy Creek, 4 miles from Hamilton". This tuff contains plants in position of growth vertically through the stratification. In addition there are fronds of a *Blechnum*-like fern horizontally along a bedding plane. J. H. Willis, of the Melbourne Herbarium

says this form does not belong to any species of *Blechnum* growing in Australia at the present time. "There are no living representatives with the secondary lateral veins so close (3-4 per mm.)." The matrix has the appearance of a very fine silt, but on decanting proved to have practically no clay. Nevertheless the material acted somewhat like a clay in that it stuck to the evaporating dish and cracked on drying. This appears to be due to the large percentage of chloritic material present. The light fraction is mostly chloritic material and quartz is very rare. Mica is present. There is a small assemblage of heavy minerals, which are angular. Fresh, sharp-edged grains of olivine are common and the opaques include magnetite. No zircons were seen. There are cloudy grains which are probably altered mica. I am much indebted to Dr. A. W. Beasley for considerable help with the mineralogical work. The matrix of the fossil fern is thus a very fine tuff and a swampy or lacustrine ecology is indicated. This sample may well belong to the higher part of the tuff formation where weathering had taken place (hence the chloritic material), and ferns were growing. The amount of weathering shows that there was a break between the deposition of the tuff concerned and the emplacement of the rock now above it—probably the basalt. A sample of this tuff was washed for microfossils but none were found, not even a sponge spicule. Further field work will no doubt elucidate the succession, but there is enough evidence to say that a volcano was active nearby so that tuff was ejected into the sea, but during the deposition of the tuff, the sea retreated so that ferns grew where earlier marine fossils were deposited. The thickness of the tuff does not seem to account for this retreat of the sea, and tectonic uplift provides a more feasible hypothesis.

The lack of sedimentary evidence for the presence of the Grampian Mountains at that time (p. 150), and the evidence of uplift and faulting associated with the vulcanism in this area, prompt the idea that the Grampians were elevated in Upper Pliocene time.

On Grange Burn a calcareous sandstone overlies the Kalimnan shell bed and underlies the basalt. There is no tuff. On Muddy Creek, the tuff overlies the Kalimnan shell bed and underlies the basalt. There is no calcareous sandstone. The site of the buried soil with fossil Cuscus is only a little over a mile in a direct line from MacDonald's Bank on Muddy Creek where the tuff occurs. The fact that no tuff bed occurs on Grange Burn suggests that the volcano was rather to the south of Muddy Creek. However, a sample of the soil in which the Cuscus tooth was

found was examined mineralogically to see if there were any trace of volcanic ash. Quartz is the commonest mineral, and the grains are sub-angular. There are hackly olivine grains like those found in the Muddy Creek tuff. The opaques have some grains angular and some rounded. Tourmaline is present, and zircons, which are small. White mica and carbonaceous material are obvious constituents. There is thus evidence that some volcanic ash fell on the Grange Burn area but not enough to form a tuff deposit.

The whole of this late Tertiary terrain was later sealed off with widespread basalt flows.

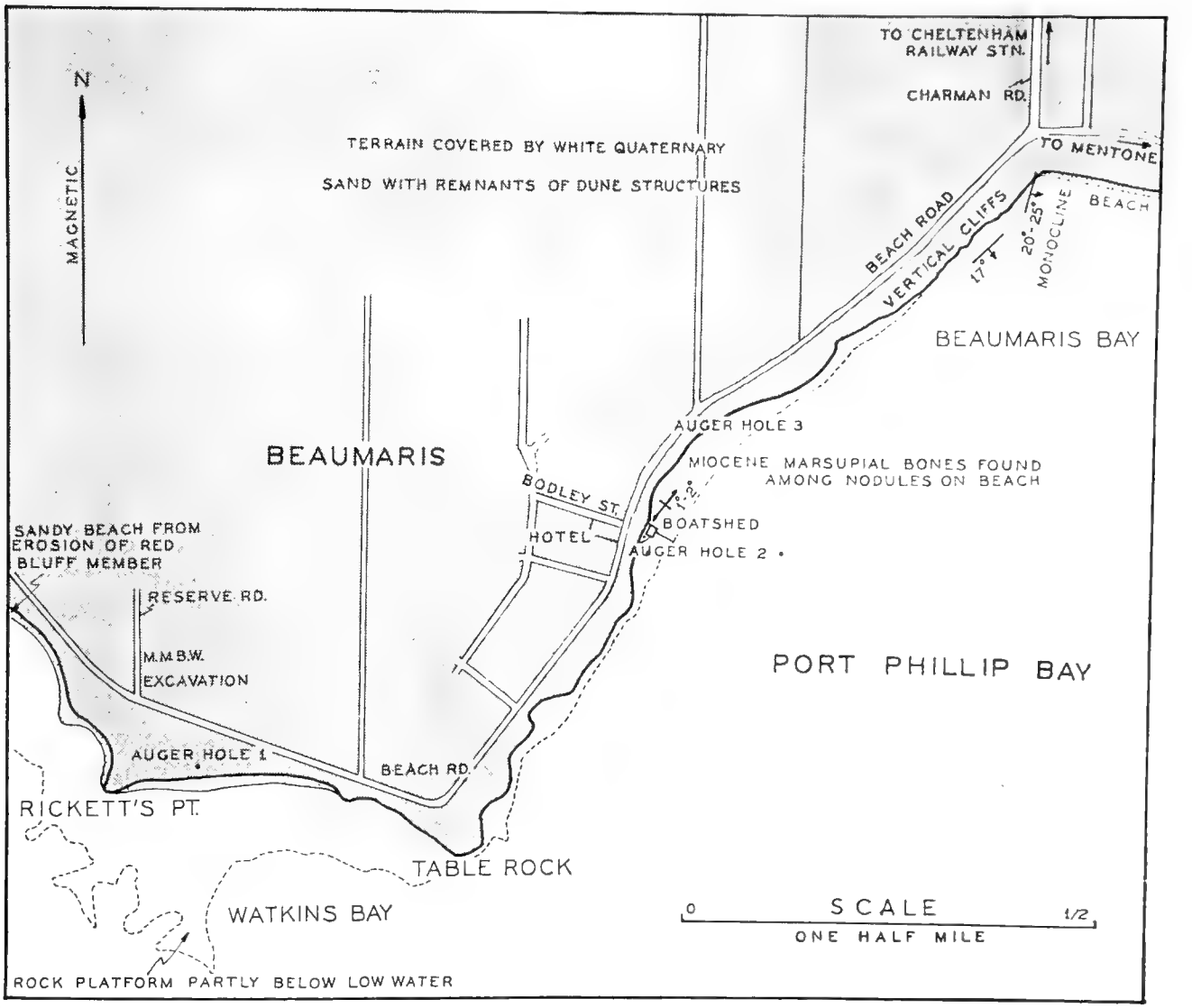
Environment of the Hamilton Fossil Marsupials.—

(*a*) *The Macropod.*—This kangaroo lived in Lower Pliocene time in a warm temperate or sub-tropical climate, as is indicated by the rich marine fauna with warm water elements. The animal was washed out to sea where a portion of the ramus was preserved in a shallow water marine coquinoid. This is the only evidence of Lower Pliocene marsupial life found so far in Victoria.

(*b*) *The Cuscus.*—A warm temperate or sub-tropical rain forest covered what is now the Hamilton District in Upper Pliocene time. Some ecologists would call such a forest a wet sclerophyll forest, retaining the name "rain forest" for one entirely without *Eucalyptus*. The forest at Hamilton was chiefly a coniferous one, but the eucalypts, wattles, and sheoaks that characterize the extant flora were also well represented. Ferns were common. Freshwater lakes were rich in diatoms and sponges. The terrain was flat and swampy, and the underlying limestone was leached to give a "podsolic" soil, not a *terra rossa*. The tooth of a cuscus found by the writer in the buried soil under the basalt is the only vertebrate fossil discovered so far. The living cuscus is a rain forest inhabitant in tropical areas, occurring "from Timor and Celebes through New Guinea to the Solomons and Cape York. . . In addition to a diet of leaves and fruit, it is said they will catch and eat birds and other small animals." (Troughton, 1951.) The presence of *Cuscus* at Hamilton fits in with the evidence for a climate warmer and wetter than the present.

C. Occurrence of Tertiary Marsupials at Beaumaris, Victoria.

The sea cliffs at Beaumaris are different from those found elsewhere on the east side of Port Phillip Bay. Being more lithified than the rocks that form the sloping cliffs of most of the N.-E. shore of the Bay, they constitute at Beaumaris a small promontory with vertical cliffs. An asymmetrical pitching anticline brings up these rocks from their usual position near sea-level to form cliffs about 50 feet high. At Rickett's Point, ironstone outcrops between tide marks, then further east it rises gradually to form the cliffs at Beaumaris. The axis of the anticline is at



Text-figure 11.—Locality map of Beaumaris, Victoria, showing structure (after Hall and Pritchard 1897), the sites of auger holes, and fossil localities. Vertical cliffs occur where the Black Rock Member outcrops, and sloping cliffs with sandy beaches characterize the coast where the Red Bluff Member outcrops. The map is based on aerial photographs.

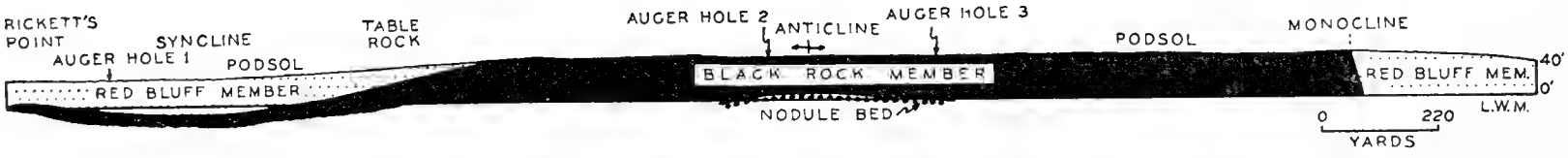
the Beaumaris boatsheds, then with a low dip of only a degree or two the beds dip towards Mentone. However, at the end of Charman-road the beds dip suddenly at 20° to 25° (strike E.25° S.) in a monocline, and thus disappear below sea-level. A short distance S.-W. of the monocline, the strike swings a little so that it is parallel to the shore from there to Table Rock. This swing in the strike can be seen by the curve of a reef of ironstone visible in the sea at low tide. The monocline is associated with a change in direction of the coastline, and with the sudden change from vertical cliffs of highly fossiliferous and ferruginous marine beds to more or less unfossiliferous, non-ferruginous softer fresh-water beds which form sloping cliffs easily eroded.

The general structure of the beds at Beaumaris is shown in text-fig. 12, where the anticline and monocline are indicated in a diagrammatic section from Rickett's Point to Mentone Beach. The two types of beds referred to above have been included in the Sandringham Sands formation (Gill, 1950). The type section is Red Bluff, Sandringham. Since the above paper was written, the author has carried out further work on these strata, and it is clear now that the two types of beds at Beaumaris are two members of the formation which can be seen at Red Bluff and traced on through the suburbs of Melbourne to Keilor, a distance of some 25 miles. It is therefore here proposed that the following subdivision be recognized:—

Formation.	*Members.*
Sandringham Sands ..	2. Red Bluff (Younger)
	1. Black Rock (Older).

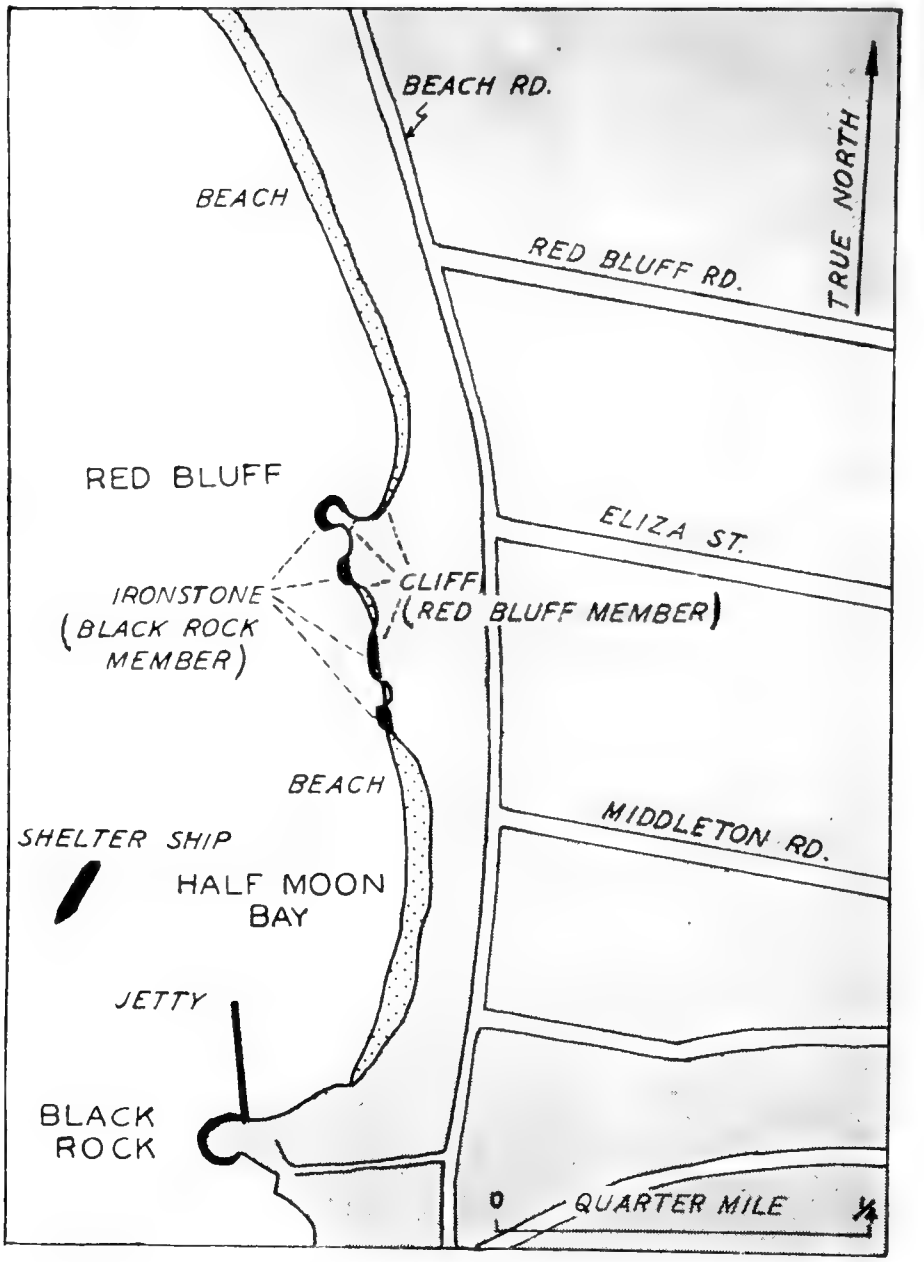
The stratigraphically higher Red Bluff member is a non-marine (mostly fluviatile) one, while the lower Black Rock member is marine. The definition of these members in the type section of the Sandringham Sands Formation at Red Bluff is shown in text-fig. 13.

1. *Red Bluff Member.*—This is named after Red Bluff, Sandringham, the type section of the Sandringham Sands formation. At Red Bluff it consists of about 78 feet of clayey sands, off-white to various pastel tints in colour, red being common and hence the name of the bluff. Generally speaking, the lowest part of the member consists of sands, the large median part of sands, gravels, and conglomerates, and the highest part of sands again. This three-fold subdivision of the member can be recognized all over Melbourne and is particularly well shown in many sections up the Maribyrnong River valley. Foundry molding sands are taken usually from the comparatively thin top and bottom sections which

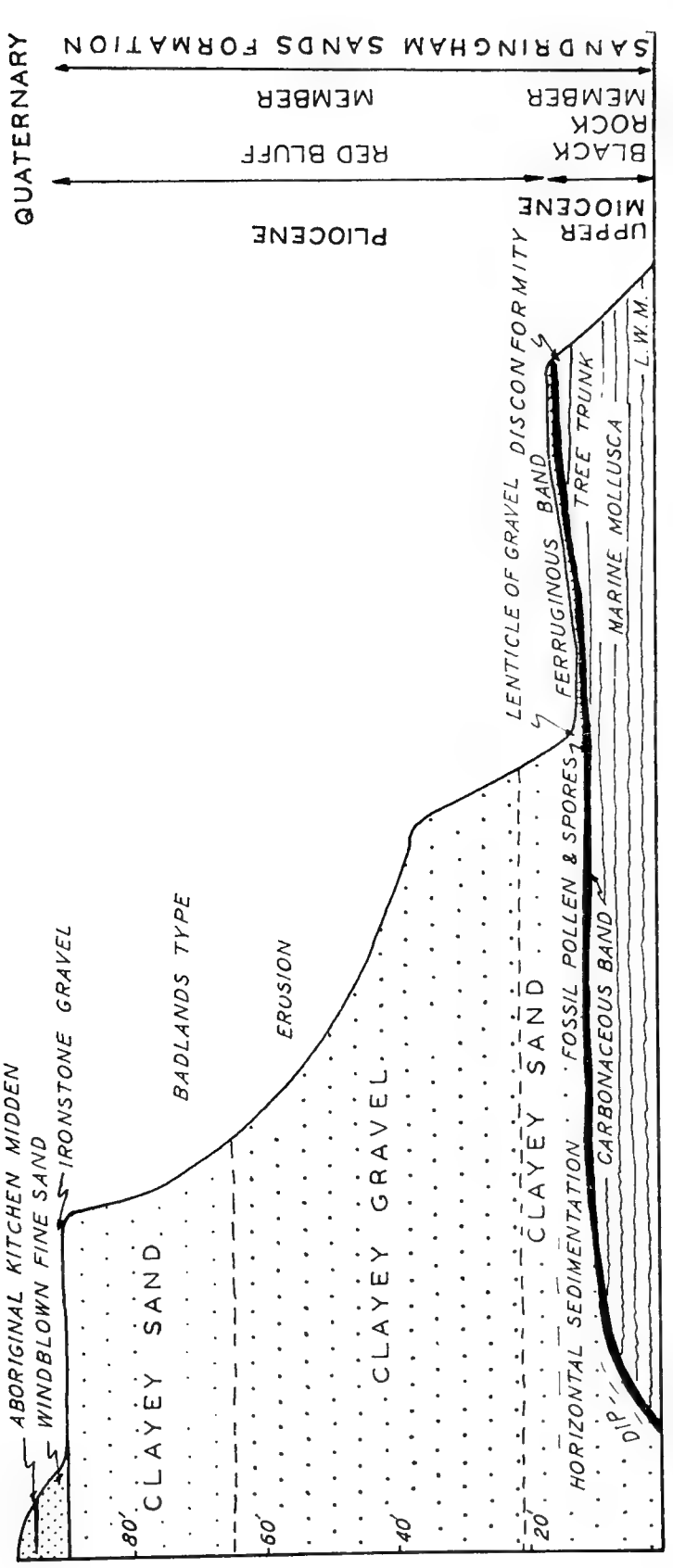


TEXT-FIGURE 12.—Diagrammatic section of coastal cliffs from Rickett's Point to Table Rock, to Charman-road, Beaumaris, Victoria, showing the author's interpretation of the relationships of the Black Rock and Red Bluff members in this area. There is a vertical exaggeration of nearly five times, so the dips are much steeper than in reality. For localities see Text-figure 11.

often consist of a fairly fine and well-sorted sand. Evenness of grain size is probably due to derivation from marine-sorted beds. Because these layers of desirable sand are comparatively thin, they have often been won by tunneling. In many places there are clay balls and clay lenticles in the median coarse section, and these sometimes contain fossil leaves. The clay lenticles, the presence of fossil wood, and the carbonaceous seams mentioned in the next paragraph are evidence of the non-marine origin of the Red Bluff member.



TEXT-FIGURE 13A.—Locality map, Sandringham and Black Rock, Melbourne, Victoria.



TEXT-FIGURE 13B.—Diagrammatic section at Red Bluff, Sandringham, type section of the Sandringham Sands formation. The subdivisions of the Red Bluff member are not well defined, and so are represented by broken lines.

Red Bluff consists of a high sloping cliff with a platform at its base. This platform is not due to a higher eustatic sea, but to differential erosion. The platform consists of the much harder Black Rock member on which is a seam of carbonaceous sand capped by a thin iron pan. The carbonaceous sand is the base of the Red Bluff member, but it has apparently held up percolating waters containing iron so that this has been deposited at that level. The top of the platform is not level, following slight dips of up to 5° in this iron pan. As shown in text-fig. 13B this carbonaceous seam cuts out near beach level. At its inland extremity it dips at various angles up to 15°. The overlying beds are practically horizontal so the dips are probably due to penecontemporaneous slumping. At the various points along the coast where the Black Rock member comes to the surface, this outcropping is due to low anticlines or inter-member erosion. The largest tectonic movement is that shown by the anticline and monocline at Beaumaris. The carbonaceous seam at Red Bluff is generally about 1 foot in thickness but it attains 2 feet in places. The carbon content varies somewhat, but from a sample collected by the writer, Miss Kathleen Pike was able to recognize the following:—

Hystrichosphaeridium tubiferum.
Cyathea and other spores.
Nothofagus species A of Cookson, 1946.
Nothofagus species F of Cookson, 1946.
Nothofagus species J of Cookson, 1946.
Myrtaceidites eucalyptoides forma *orthus.*
Fragments of cuticle and wood.

The *Hystrichosphaeridium* is a marine fossil (Cookson, 1953), but is often found in near-shore deposits, whence it can easily be wind-borne. The remainder of the forms are terrestrial. The ecology was probably that of a near-shore lagoon or swamp probably like the Albert Park Lake or Elwood Swamp in Melbourne before European settlement changed them.

The age of the carbonaceous seam is no doubt Tertiary as is indicated by the wealth of beeches and the fact that the species A, F, and J of *Nothofagus* have not been found in Quaternary beds. As the Red Bluff member rests disconformably on the Black Rock member which is Upper Miocene in age, the former can be taken to be of Pliocene age. The disconformity between the two members is the result of the erosive work of the sea as it retreated. A lenticle of carbonaceous material similar to that at Red Bluff was found at beach level at Hampton by Mr. H. T. Clifford (personal

communication). Hart (1893) mentioned the one at Red Bluff and others at Mentone. The Victorian Mines Department (1938) put down four bores in the Yarra Yarra Golf Links near the corner of Warrigal and Centre roads, Moorabbin, 4½ miles inland from Port Phillip Bay. Bore 3 struck 5 feet of " ligneous clay " at 116 to 121 feet from the surface which is not far from the 150-foot contour of the Military Map. That the ligneous clay is found in only one of four closely spaced bores suggests that its occurrence is lenticular. The clay rests on a limestone. In the W. J. Parr collection in the National Museum are a couple of samples from a water bore put down in 1939 in the Victoria Golf Club's property, Park-road, Cheltenham, about 1½ miles from Port Phillip Bay. Over a marine limestone there occurred in this bore at 217 feet a grey, carbonaceous, non-calcareous siltstone with sponge spicules. Miss Kathleen M. Pike kindly examined this sample and was able to identify:—

Nothofagus spp. E, F, J of Cookson (1946).
Casuarinidites cainozoicus.
Myrtaceidites parvus.
M. mesonesus.
M. eugenioides.
Dacrydiumites mawsonii.
D. florinii.
Triorites harrisii.
?Epacridaceae.
Fern spores.
Hystrichosphaerideae.

It will be noted that this flora is of a type similar to that from Red Bluff. The driller's sample also included sandy material which contained shell fragments, foraminifera, ostracods, bryozoa, and plant remains. Small mollusca in the sample were filled with grey carbonaceous silt. The sample may well be evidence of a former shoreline lagoon where terrestrial and marine fossils mixed, such as in the Elwood Swamp area at the present time where marine shells are found admixed with material rich in pollen, spores, &c. (Cookson, 1954). It is interesting to note the occurrence of these carbonaceous horizons in the same area as the shoreline outcrops. More will be said later about the limestones and their age, but along the coast in this area and in river valley sections wherever the Red Bluff member is resting on other sedimentary rocks, these are invariably the Black Rock member. Keble (1950) described the Baxter Sandstones of the Mornington

Peninsula and regarded them (p. 42) as "the terrestrial phase contemporaneous with the Cheltenhamian". Other clays and sands were regarded by him as Pliocene in age. What the relationship is between the Baxter Sandstones and the post-Cheltenhamian Red Bluff member is not known, but it is possible that they are homologous.

2. *The White Sands.*—It will be noted from the section of Red Bluff in text-fig. 13B that the white sands at the top of the cliff are not included in the Red Bluff member nor are they given a formational name. They were similarly excluded from the definition of the Sandringham Sands formation (Gill, 1950). These white sands appear to be a pedological product or weathering residue or loipon from the breakdown of the underlying formation. Carroll (1949) found no mineralogical break between the rocks at Beaumaris and the overlying white sands. An indication of the age of the sands is given by the following considerations: –

(*a*) The white sands overlie both the Black Rock and Red Bluff members and therefore are younger. They cap the truncated Beaumaris anticline and so are later than the earth movements affecting the above two members.

(*b*) They do not occur on the Red Bluff member where it is covered by Newer Basalt, and the sands are therefore later than the basalt.

(*c*) The white sands have on them a podsol soil (Patton, 1933) which by comparison with other soils in Victoria dated by radiocarbon (Gill, 1953 E, F, 1954B) one would expect to be Holocene in age.

(*d*) The white sands have a dune topography, and so an aeolian origin. That the dune profiles are still fairly well preserved is an indication of recent formation. The dunes were formed in a time drier than the present, for they are now immobilized by vegetation.

While the white sands themselves have been in process of formation for a long time, they assumed their present form in a recent dry period. This could have been the mid-Holocene arid period of about 5,000 years ago.

3. *The Black Rock Member.*—The differences between the Red Bluff member and the underlying Black Rock member are summarized in text-fig. 14. The name of the latter member is from

SANDRINGHAM SANDS FORMATION.

Red Bluff Member.	Black Rock Member.
1. Sands and gravels, generally clayey	1. Sandstones to marly sands
2. Non-ferruginous	2. Ferruginous, commonly forming ironstone
3. Non-calcareous	3. Calcareous, or originally so
4. Lenticles and balls of pipeclay	4. No clay seams
5. Beds and lenticles of carbonaceous sediments	5. Non-carbonaceous
6. Not lithified	6. Lithified
7. Fossil wood, leaves, pollen, spores, freshwater sponge spicules ; marine dinoflagellates in carbonaceous sediments at seaward end of member	7. Fossil whales, dolphins, sharks, rays, fish, cephalopods, mollusca, brachiopods, foraminifera, echinoderms, corals, polyzoa and crustacea. A few marsupial bones from one site
8. Cliffs sloping, and suffer badlands erosion	8. Cliffs vertical, and break off in sections
9. Pastel shades of grey, yellow, red, &c.	9. Yellowish-brown and reddish-brown to very dark brown
10. No stratification	10. Stratified
11. Current bedding common	11. Current bedding not characteristic

TEXT-FIGURE 14.—Comparison and contrast of the two members of the Sandringham Sands Formation.

the suburb of Black Rock which appears to have been named from an outcrop on the beach of the dark Black Rock member. The two members are alike in their high percentages of quartz, the grains of which are well rounded, having experienced a number of cycles of erosion. Carroll (1949) has given the following sand clay analyses:—

	Sand %	Clay %
White sands overlying Black Rock member at Beaumaris	75	25
Red Bluff member at Mentone ..	90	10
Black Rock member at Beaumaris ..	81	19

Carroll states that " Both the mechanical composition and the mineralogy of the Cheltenhamian beds at Beaumaris indicate that the source of the material was in pre-existing sedimentary rocks ". " Both lithologically and mineralogically there is a break in sedimentation between the Cheltenhamian beds and the presumably overlying white sandstone at Mentone." In other words, there is a clear mineralogical difference between the Red Bluff member and the Black Rock member. It should be noted that for convenience Dr. Carroll took the whole of the Black Rock member at Beaumaris as " Cheltenhamian beds ", but in his definition of this stage Singleton (1941) limited it to the lower 20 feet of strata because he could not find fossils in the upper beds and so could not determine their age.

In the type section for the Sandringham Sands formation at Red Bluff, Sandringham, the Black Rock member is represented by 6 to 10 feet of brown fine-grained sandstone from which Hall and Pritchard (1897) have recorded a fauna of sixteen marine species. The rocks are highly ferruginous and the " small lenticular sheets of a hard grey limestone " referred to by the above authors may appear calcareous but are not. The Black Rock member here owes its elevation above sea-level to a low anticline. At a number of places along this coastline the Black Rock member rises above sea-level, apparently elevated by rolls or low anticlines. Hall and Pritchard (1897) record fossils from some of these localities, one of which is Rickett's Point (see text-fig. 11), an ironstone outcrop included by Singleton in his mapping of the type Cheltenhamian outcrops. However, this appears to be the ironstone high in the type section near the boatsheds which Singleton (1941, p. 35) excluded from his definition of the Cheltenhamian, and if this be so, then the ironstone at Rickett's Point is not Cheltenhamian. If it is Cheltenhamian, then the rocks that form the lower part of the member at Beaumaris boatsheds here constitute the top of the member, and considerable erosion has taken place; also there has been lateral change in lithology. If the ironstone at Rickett's Point is Cheltenhamian, then the Red Bluff member rests directly on Cheltenhamian at Rickett's Point, but at the Beaumaris boatsheds there are some 20 feet of non-Cheltenhamian rocks on top of the Cheltenhamian which do not belong to the Red Bluff Member.

Between Rickett's Point and Table Rock is Watkins Bay which is interpreted as resulting from the dipping of the ironstone below sea-level before rising to form the Beaumaris cliffs. Near the centre line of this bay an auger hole was put down on the flat

a few feet above high water level and behind the bathing sheds. The section proved was as follows:—

Auger Hole 1.—

0 ft. to 2 ft.—Dark-grey sand including carbonaceous matter and marine shells (*Subninella, Mytilus*). Remains of a small aboriginal kitchen midden. Band of shells at 16 ins.

2 ft. to 4 ft. 8 ins.—Fine yellowish siliceous sand similar to beach sand.

4 ft. 8 ins. to 5 ft. 9 ins.—Gravel and fine conglomerate. Consists of coarse quartz sand with quartz pebbles up to ¼ in. diameter, and ironstone pebbles up to 2 ins. diameter.

5 ft. 9 ins. to 12 ft.—Mottled light-grey and fawn, fine, slightly clayey sand which is weathered for the first foot and partly so for the next foot. Thereafter fresh until 12 ft. where it became darker, coarser, and too hard to cut with the auger. The ground water level stood at 8 ft. (14.10.54). Samples at various levels were washed and found to consist mostly of clear quartz sand, with occasional mica flakes. The clay percentage is very low, the binding agency apparently being the fine silt fraction.

The above section is interpreted thus:—

0 ft. to 5 ft. 9 ins.—Quaternary sediments.

5 ft. 9 ins. to 12 ft.—Red Bluff member with weathered surface (a juvenile soil).

12 ft.—Probably Black Rock member.

In recent years a number of excavations have been made in the Red Bluff member in this district for sewerage pumping stations (e.g., corner Beach and Reserve roads, Beaumaris) and drainage works, and the fresh material excavated is very similar to that found in the Watkins Bay auger hole from 5 ft. 9 ins. to 12 ft.

At the base of the Black Rock member is a nodule bed (Hart, 1893; Hall and Pritchard, 1897; Cudmore, 1926; Singleton, 1941) which is brought to beach level at the axis of the Beaumaris anticline. This nodule bed marks a disconformity. The bed under the nodule bed nowhere outcrops at the present time, and so two auger holes (Nos. 2 and 3) were put down to determine the nature and age of the underlying bed in the vicinity of the two points at which Singleton measured sections when defining his Cheltenhamian Stage.

Auger Hole 2.—On the Beaumaris beach west of the boatsheds and below the end of Bodley-street. If the line of the brick wall forming the rear of the boatsheds is extended 27 ft. west, a site is reached 3 ft. 9 ins. from the cliff where the auger hole was put down. Because of difficulty caused by the nodules, a hole was dug with a spade to 3 ft., and then continued with the auger. The section from beach level (not more than a foot above H.W.M.) was as follows:—

0 in. to 6 ins.—Cliff wash.

6 ins. to 3 ft. 3 ins.—Coarse, well-rounded, clear quartz sand with some concretionary nodules (probably from erosion of the nodule bed seaward of this point), and pebbles of marl and ironstone. Also waterworn *Lovenia*, *Monostychia* and *Ostrea*.

3 ft. 3 ins. to 4 ft. 6 ins.—Calcareous and ferruginous nodules with coarse quartz sand. Some of the calcareous nodules are much bored with marine borings, but no such borings were seen in the ferruginous ones.

4 ft. 6 ins. to 6 ft. 1 in.—Yellowish-brown marly sand rich in foraminifera and ostracods.

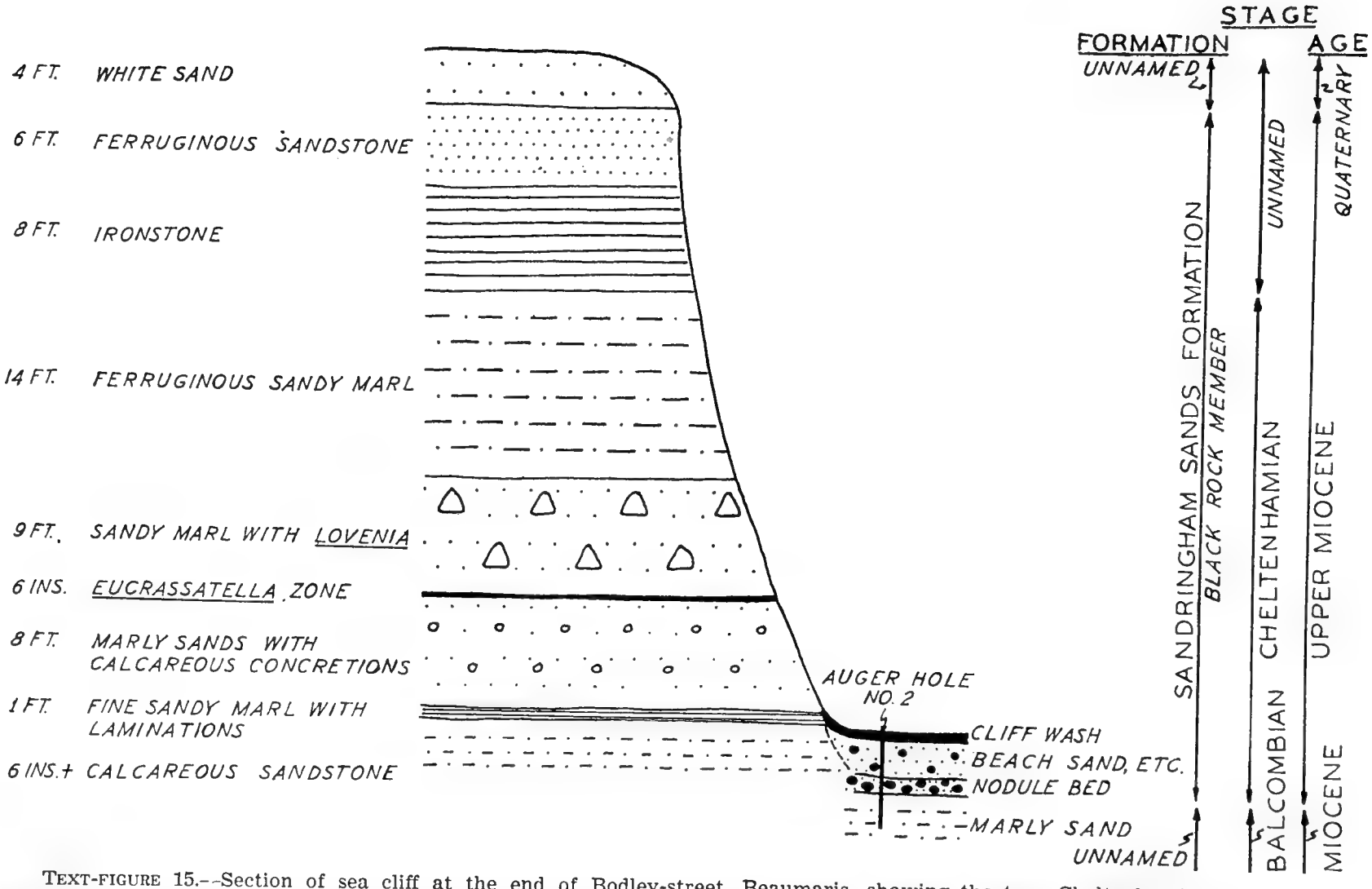
At 6 ft. 1 in. a hard calcareous band was encountered with water flowing over it. An unsuccessful attempt was made to punch through this band with a fencing bar.

Auger Hole 3.—On the Beaumaris beach near the former baths. From the path that descends the cliff, two rows of piles mark where a platform once led out to the baths. The platform ran for a short distance at an oblique angle to the cliff, then at right angles to the cliff straight out to the baths. The post marking the change of direction of this platform (25 ft. from the cliff) was used as a bench mark. Auger Hole 3 was 35 ft. east of this post and 15 ft. 9 ins. from the cliff. The beach level at this spot is below H.W.M. and so lower than that at Auger Hole 2. The section encountered was as follows:—

0 ft. to 1 ft.—Beach sand, concretionary nodules, and pebbles.

1 ft. to 5 ft. 9 ins.—Yellowish-brown marly sand as found in Auger Hole 2, with nodules.

In this section there was trouble with nodules jamming the auger, and the hole was abandoned eventually because of this difficulty. However, the succession was clarified. At both sites the nodule bed is underlain as it is overlain by marly sands. In text-fig. 15,



TEXT-FIGURE 15.—Section of sea cliff at the end of Bodley-street, Beaumaris, showing the type Cheltenhamian beds. The detail of the cliff exposures is after Singleton (1941), while Auger Hole No. 2 is that put down by the writer.

It may well be that the sediments under the nodule bed should also be included in the Sandringham Sands formation, but this question is left open until more is known about them.

Singleton's section west of the boatsheds is represented diagrammatically with the addition of the information from Auger Hole 2. The complete succession may be summarized thus:—

4 ft.—Quaternary whitish sands, windblown in part at least.
14 ft.—Highly ferruginous sands.
About 35 ft.—Brownish calcareous sands. Nodule bed.
2 ft. plus.—Yellowish-brown calcareous sands.

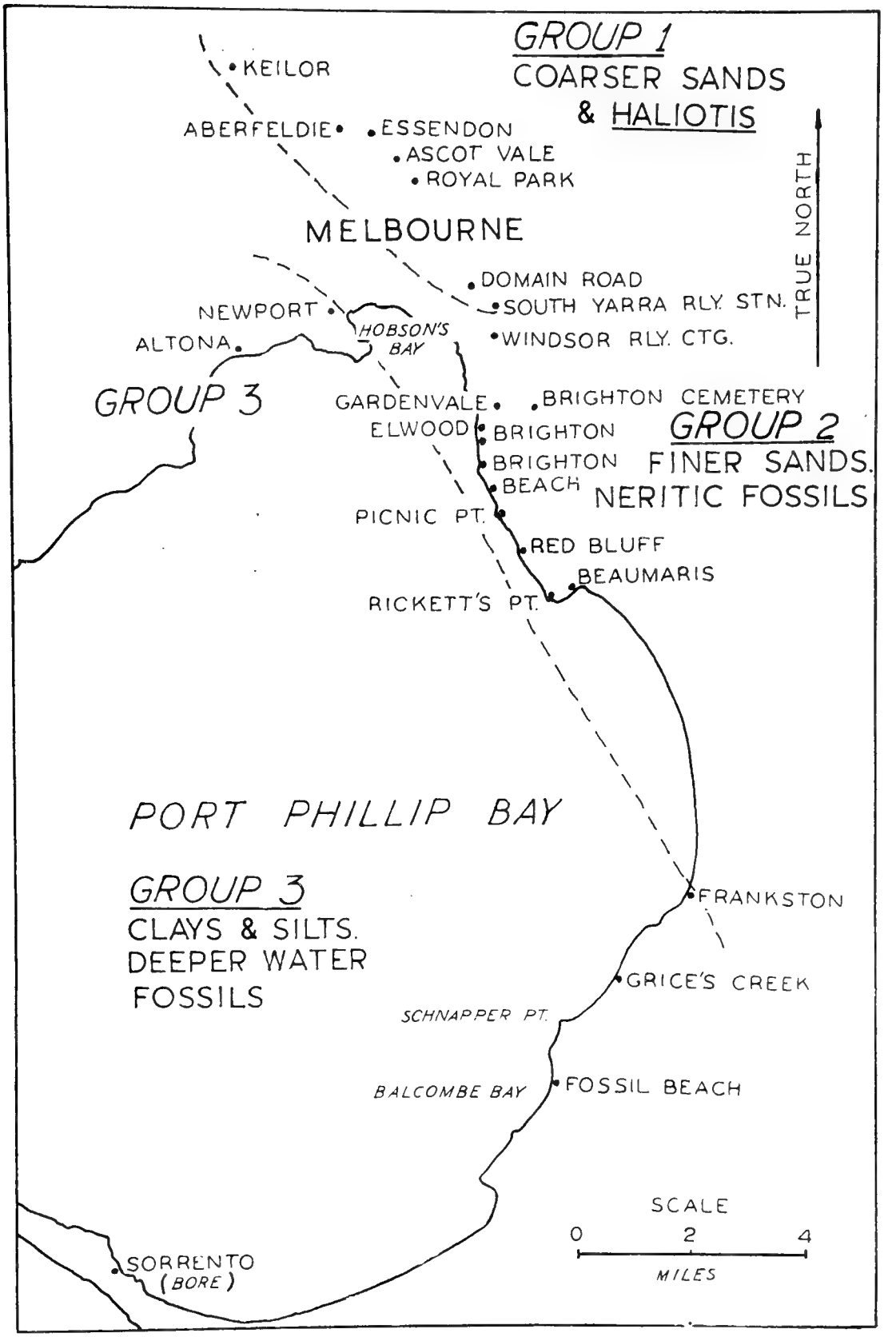
As the same type of sediment occurs above and below the nodule bed, the time taken to form it was not great enough for a change in facies to take place. There is a difference in the faunas above and below the nodule bed, but the difference in age is not a great one. The bed below the nodule bed is Balcombian (Singleton, 1941), while the nodule bed and above is Cheltenhamian. This marly sand facies of the Balcombian in intermediate between the calcareous clays of the type area at Balcombe Bay and the ferruginous sands and gravels (originally calcareous as shown by the numerous casts and moulds of molluscs) of the shoreline facies to be seen at Royal Park, Essendon, and Keilor (see text-fig. 16). The facies of the Black Rock Member is a near-shore one, as is shown by the nature of the sediments and the enclosed fossils. The sediments are sands and gravels (fine conglomerate in places) with admixed calcareous matter. Singleton (1941) said the sediments were glauconitic but Carroll (1949) claimed that she could only recognize nontronite. At spring low tide I dug a spade hole and extracted greenish marl sand which turned a fawn shade on drying. This colour change is probably due to nontronite, but in the same sample Mr. George Baker recognized glauconite. However, it is not plentiful. Glauconite forms in shallow waters. The presence of the bones of a number of land animals (the marsupials) also shows the site was near land. The marine fauna includes near-shore mollusca and barnacles. A fossil crab (P.15863) sent to Dr. M. F. Glaessner for identification proved to be *Persephona* sp. nov., a shallow water form. Evidence of appreciable currents is provided by rolled specimens of large bones (such as whale bones), pebbles, and current bedding (chiefly

TEXT-FIGURE 16.—Map showing the change from coarser to finer sediments in the Miocene marine Red Bluff member of the Sandringham Sands formation.

Group 1 localities have sandy sediments, often very coarse. They have the shoreline gasteropod *Haliotis*, and some have other shoreline forms such as *Turbo* and limpets.

Group 2 localities have generally finer sandy sediments, and while not possessing the above shoreline molluscs, have numerous shallow water fossils.

Group 3 localities are characterized by a calcareous silt to clay deeper water facies with appropriate fauna.


GROUP 1
COARSER SANDS
& HALIOTIS
KEILOR
ABERFELDIE
ESSENDON
ASCOT VALE
ROYAL PARK
MELBOURNE
TRUE NORTH
DOMAIN ROAD
SOUTH YARRA RLY. STN.
WINDSOR RLY. CTG.
NEWPORT
HOBSON'S BAY
ALTONA
GROUP 3
GARDENVALE
BRIGHTON CEMETERY
ELWOOD
BRIGHTON
GROUP 2
BRIGHTON
FINER SANDS.
BEACH
NERITIC FOSSILS
PICNIC PT.
RED BLUFF
BEAUMARIS
RICKETT'S PT.
PORT PHILLIP BAY
GROUP 3
CLAYS & SILTS.
DEEPER WATER
FOSSILS
FRANKSTON
GRICE'S CREEK
SCHNAPPER PT.
BALCOMBE BAY
FOSSIL BEACH
SCALE
0 2 4
MILES
SORRENTO
(BORE)

in the higher beds). The Black Rock Member is marine throughout, but in the higher part of the sequence at Beaumaris, Singleton (1935) found fossil leaves which he referred to *Cinnamomum*. Plant remains have been found high in the same member associated with marine fossils at South Yarra, Royal Park, Ascot Vale, and Keilor (three localities in Green Gully were found by Mr. Ron Wilkins). A log of wood was found in the same stratigraphical horizon at Red Bluff (Hart, 1893). The leaves and wood are at the top of the Black Rock member, and with the sediments indicate a time when the waters were shallowing due to the retreat of the sea. This marine member is succeeded by the non-marine Red Bluff member.

Palaeontology.—Hall and Pritchard (1897) listed over 100 species of fossils from the Black Rock member at Beaumaris, and later writers have extended their list considerably. The late W. J. Parr (MSS) has listed the following foraminifera from the "*Neotrigonia* bed near base of cliffs, 300 yards east of baths":—

Amphistegina lessonii (derived).
Anomalina nonionoides.
Cibicides ingerianus.
C. lobatulus.
C. mundulus.
C. refulgens.
Dimorphina tuberosa.
Discorbis bertheloti.
D. turbo.
Elphidium crispum.
E. macellum.
E. striatopunctatum.
E. verriculatum.
Lenticulina orbicularis.
Orbulina universa.
Rotalia beccarii.
R. compressiuscula.
Siphonina australis.
Spirillina decorata.

Cudmore (1926) listed the vertebrates known from Beaumaris. They comprise two species of whales, a dolphin, 28 species of

sharks, eight species of rays and sawfish, and two marsupials. In the National Museum Collection there are also some fish jaws (not yet described), and an carbone of a whale (P.16195) collected by Dr. G. B. Pritchard and determined by the British Museum for him as cf. *Balaena,* i.e., a whalebone whale, whereas those recorded previously are toothed whales. A collection of fossil teeth from Beaumaris made by D. K. Holloway includes *Oplegnathus manni* Chapman and Cudmore (1924, p. 145) which the authors described as restricted to the Kalimnan (including the Cheltenhamian stage which was erected later). The Knife-Jaw *Oplegnathus woodwardi* is still living in Australian waters. A further new record since Cudmore listed the fauna is that of an anterior tooth of *Squalodon* cf. *wilkinsoni* McCoy (P.16198) collected from the " basal beds, Beaumaris ", and presented to the National Museum by J. M. Wilson, 28th August, 1921 (see Singleton, 1935, p. 131). The following table sets out the fossils occurring at Beaumaris which appear to be of stratigraphical significance:—

Fossil.	Range.		
	Balcombian.	Cheltenhamian.	Kalimnan.
MOLLUSCA—			
Aturia australis McCoy			
Limopsis beaumariensis Chapman	?		
Neotrigonia acuticostata McCoy			
VERTEBRATA—			
Carcharias collata Eastman			
C (Prionodon) javanus Martin			
Edaphon mirabilis Chapman and Cudmore*			
E. sweeti Chapman and Pritchard			
Galeocerdo latidens Agassiz	?		
Myliobatis moorabbinensis Chapman and Pritchard*			
Notidanus jenningsi Chapman and Pritchard*			
Nummopalatus depressus Chapman and Pritchard			
Oplegnathus manni Chapman and Cudmore			
Pristis cudmorei Chapman*			

* Known only from Beaumaris.

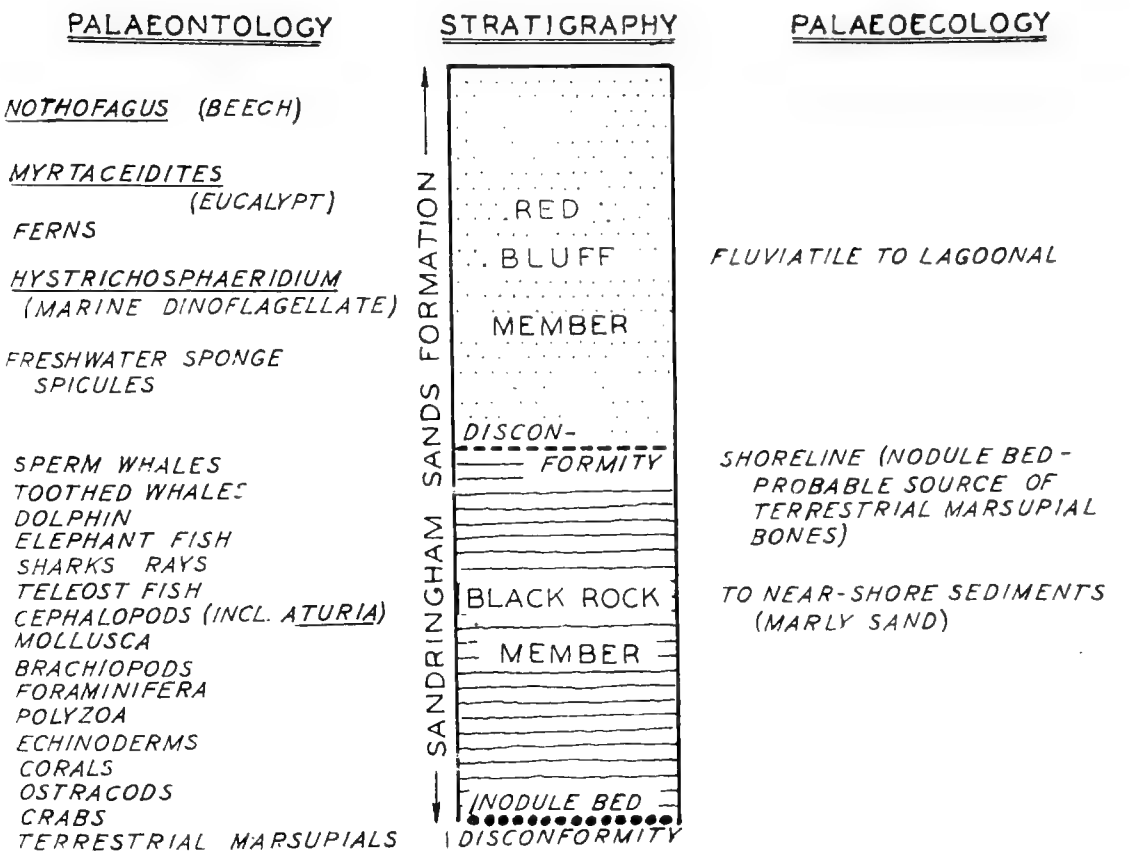
Most of the vertebrate fossils at Beaumaris appear to have come from the nodule bed which is a concentration of calcareous nodules, ferruginous nodules or pebbles, and vertebrate remains. The matrix is a coarse clear-quartz sand. The calcareous nodules

are not phosphatic, but the ferruginous nodules are slightly so. The accumulation of derived nodules, and the coarseness of the sand matrix indicate the presence of comparatively strong currents. What thickness of beds (if any) was removed is not known. Probably a temporary shallowing of the sea caused erosion and so the aggregation of the nodules, then as the sea became deeper and quieter the coarse sand gathered, then the fine marly sand on top. A sample of this marly sand tested for phosphate showed a small amount present. The phosphate may be from the erosion of whale and other bones. A thorough mineralogical and chemical study of the nodule bed could throw a great deal of light on its history. The period of time represented by the nodule bed is probably small geologically speaking because:

1. On present knowledge there is no missing Stage between the beds above and below, as there is in the Hamilton district.
2. The sediments above and below the nodule bed are the same i.e., marly sand.

During the formation of the nodule bed the shore was presumably not far away, and this may well have been the time during which most of the marsupial bones were introduced into the sediments of the Black Rock member. If so, they can be dated very precisely.

Although vertebrate fossils are commonest in the nodule bed, they occur both above and below this horizon, as can be seen by the specimens used for the fluorine test. The holotype of *Scaldicetus macgeei* came from " 6 ft. to 10 ft. above H.W.M., Beaumaris " (Chapman, 1912). F. A. Cudmore collected a dorsal rib of a whale nearly 6 feet long from " the cliff near the point ", i.e., above the nodule bed. In the Cudmore Collection in the National Museum are sharks' teeth still in their matrices and thus providing some evidence of the bed from which they are derived. Allan Keefer found a large part of the skull of a toothed whale (P. 16204-16207) claimed to be " *in situ* on the sea bed beneath the jetty as it leaves the boatshed ". This fossil is encased in ironstone and so presumably comes from the ironstone band above the Cheltenhamian as defined by Singleton but still in the Black Rock member. The palaeontology and palaeoecology of the Sandringham Sands formation are summarized in text-fig. 17.



TEXT-FIGURE 17.—Summary of the palaeontology and palaeoecology of the two members of the Sandringham Sands formation.

Bore samples.—To the foregoing description of the Sandringham Sands formation and its members, there needs only to be added information from some bore cores before a review of the geological history is given. Reference has already been made to carbonaceous sediments in certain water bores put down in the southern suburbs of Melbourne. From a bore in the Victoria Golf Club's property in Park-road, Cheltenham, are samples given as from 217 feet and 221 feet respectively. Such bores are usually put down by percussion methods and the samples are not the most dependable. However, the sample from 217 feet consists of a piece of carbonaceous siltstone included in which are quartz grains, mica flakes, freshwater sponge spicules, plant remains, and what appears to be part of a seed case. With this non-calcareous siltstone are calcareous fossils such as foraminifera (large and small), shells, shell fragments, fine cidaroid spines, bryozoa, and marine ostracods, which were kindly determined by Mrs. Betty Kellett Nadeau as *Bradleya dictyon* (Brady).

Cytherelloidea sp., and *Cythereis* sp. Probably at about 217 feet there is a marine horizon, just above which is a lagoonal or similar facies from which the carbonaceous siltstone comes.

The sample from 221 feet in this bore is mostly coarse, consisting of rounded and angular pieces of clear quartz, milky quartz, grey quartz, and brownish quartz, the first predominating. Some grains are sub-spherical and highly polished; they are up to 3 mm. in diameter. Pieces of indurated siltstone, some containing minute pebbles, occur up to ¼ in. diameter and occasionally more. Small ferruginous pebbles occur in the siltstone and separately; they generally have a glaze. Most appear to be inorganic but some appear to have been internal casts of small fossils. Numerous foraminifera are so preserved, especially globigerinids. The sample also contains numerous pieces of broken and abraded molluscan shells up to ½ in. diameter. Fossils noted were pieces of marine mollusca, small marine gasteropods and lamellibranchs, bryozoa, marine sponge spicules, cidaroid spines, very numerous large foraminifera including *Lepidocyclina*, *Amphistegina*, and *Operculina*, and also small foraminifera including globigerinids. Crespin (1943) recorded *Lepidocyclina* (*Trybliolepedina*) *howchini* from " Victoria Golf Club, Cheltenham, at 221 feet ". The facies is clearly marine, and the pelagic globigerinids indicate access of the area to the open ocean. The numerous *Lepidocyclina* suggest a Batesfordian age, but they could be remanié in this particular bed as they are so worn. Different types of preservation also suggest that more than one horizon is represented. However, this sample is of great interest in that it provides evidence of the possible presence of Batesfordian sediments in this area, whereas at present the outcrop at Green Gully about 10 miles north of Melbourne (Crespin, 1926) is the only one recorded in the Melbourne area. Field work south of Keilor shows that Batesfordian limestone is more widely distributed in the Green Gully area than formerly thought.

Another bore of interest to the present subject is one put down in 1938 at the Kingston Heath Golf Links, also at Cheltenham. In the National Museum is a sample collected by the late W. J. Parr, and it comes from 136 feet. There are numerous large forams (as in the Victoria Golf Club bore), and a few small ones. Bryozoa are numerous. Fragments of mollusca, triaxial sponge spicules, and a marine ostracod (determined by Mrs. Betty Kellett Nadeau as *Cytheropteron*) are present. There is much coarse siliceous sand in the sample, nearly all clear quartz of mostly well rounded grains. Quartz pebbles up to ½ in. diameter occur, and calcareous pebbles up to 1½ in. diameter.

Parr (quoted in Singleton, 1941, p. 78) found " in the nodule bed and immediately overlying strata " some " worn and glauconite-filled remanié *Lepidocyclinae* ". No lepidocyclines have been found in the bed underlying the nodule bed and so they have probably come from the erosion of some bed further towards the shoreline of the times. Their source is probably the same as that providing the large forams in the two Cheltenhamian bores mentioned above.

General Geological History.—In Batesfordian times a tropical sea deposited sediments rich in lepidocyclines over the Batesford-Lara-Keilor-Cheltenham-Flinders area of southern Victoria, followed in Balcombian times by sediments in which these forms are comparatively rare. Enough outcrops are known of Balcombian deposits in the Port Phillip area to show a gradation from muddy to sandy to gravelly facies. At Beaumaris, the Balcombian beds of marly sand are capped by a nodule bed which represents a period of erosion, and then perhaps a short time of quiescence in which the ferruginous nodules were slightly phosphatized. The Sandringham Sands formation was next deposited —first the marine Black Rock member, which includes the type Cheltenhamian section. In the upper part of the Black Rock member are some very coarse beds becoming conglomeratic in places. At a number of localities leaves and wood have been found in the upper part of this marine member. The nature of the sediments and the included land plants suggest a shallowing sea. Disconformably above the Black Rock member is the non-marine Red Bluff member with lenticles of pollen and spore-bearing carbonaceous sediments, fossil wood, freshwater sponge spicules, and clay balls and lenticles containing *Nothofagus*-like leaves. Mild tectonic deformation then took place, and basalt was extruded over a wide area.

Tertiary Marsupials.—Over a long period of years terrestrial fossils have from time to time been found among the marine vertebrate fossils picked up on the shore platform at Beaumaris and nearby. None of the marsupials has been found *in situ*. Their preservation is like that of the Tertiary marine vertebrates found on the beach and *in situ* in the contiguous cliff. However, it was formerly thought that in Australia all the giant marsupials belonged to the Pleistocene, and so geologists were chary about accepting the marsupials as being Tertiary in age. With the introduction of the modern fluorine test it became possible to check the origin of the marsupials (Gill, 1953B), and the following are the specimens used along with the analyses obtained. The marsupials are described in the accompanying paper by Professor Stirton.

FLUORINE TEST ON TERTIARY MARSUPIALS FROM BEAUMARIS, VICTORIA.

A. Marsupial Remains *non in situ*.

Reg. No.	Fossil.	Data on Specimen.	% F.	% P_2O_5.	Fluorine Index.
P 15909 .. 15910	*Nototherium* - like Diprotodontid	Brown, heavily mineralized portion of maxilla from "Beaumaris"	2·72	31·8	8·6
M.U.G.D. .. 2020	*Nototherium* - like Diprotodontid	Upper premolar with same preservation as P 15909. Reported in 1897 by Hall and Pritchard, one of whom collected it "some years before" at Beaumaris "loose among the pebbles on the beach floor"	2·62	28·4	9·25
P 15911 ..	*Sthenurus* - like kangaroo	Very dark brown, heavily mineralized, much abraded ramus of a mandible. Found by F. A. Cudmore at Beaumaris in the shingle at low tide level, 3rd February, 1913	2·70	30·9	8·75
P 15912 ..	Wallaby ..	Dark brownish-grey not heavily mineralized fragment of maxilla. "From Mr. Bailey. Loc. Cheltenham." 18th June, 1883	0·68	27·8	2·70
P 15908 ..	*Vombatus* ..	Brown, not heavily mineralized jaw fragment. "Found on beach between Cheltenham and Mordialloc." Presented by Mr. Newberry 12th November, 1868	1·90	28·5	6·65

B. Check Fossils.

Reg. No.	Fossil.	Date on Specimen.	% F.	% P_2O_5.	Fluorine Index.
P 15906 ..	*Isurus hastalis* ..	Dark brownish-grey mineralized bony base of a tooth of the upper jaw collected by F. A. Cudmore in 1936. "Remanié from clay bed under nodule bed." "Washed ashore just west of the ruined baths on to the shingle bank at dead low tide, Beaumaris"	2·83	31·2	9·05
P 15905 ..	*Isurus hastalis* ..	Enamel tip of same tooth P 15906	2·75	36·3	7·60
P 15907 ..	*Isurus hastalis* ..	Greyish-brown mineralized bony base of tooth of lower jaw (formerly called *Isurus retroflexus* but see Leriche 1926, pls. 31–32). "From nodule bed, east end of section." Coll. F. A. Cudmore	2·87	30·4	9·45
P 15904 ..	Vertebra of shark	Brown, mineralized. Collected at Beaumaris by Dr. G. B. Pritchard	2·68	32·5	8·25
P 15913 ..	Humerus of dolphin	Dark grey, heavily mineralized ..	2·82	28·3	10·0
P 15903 ..	Articulating bone of whale flipper	Brown, mineralized. Collected at Beaumaris by E. T. Jones	1·63	20·3	8·05

NOTES ON FLUORINE TEST.

1. The notothere and kangaroo remains (P.15909-15911, M.U.G.D., 2020) are shown to originate from the cliff which stands behind the beach at Beaumaris. The fossils collected on the beach have fluorine indices comparable with those of the fossils indubitably belonging to the Black Rock member of the Sandringham Sands. The marsupials are Tertiary (Upper Miocene) in age and belong to the Cheltenhamian Stage. The whale flipper has a lower index than any of the other bony fossils collected from the Black Rock member. It may be part of the whale whose rib Cudmore collected from above the nodule bed, and so is younger than the other specimens. The lower fluorine index for the comparatively impervious enamel of the tooth of *Isurus hastalis* as against the bony root is in keeping with general experience (Gill, 1955, p. 110). The two parts of the same tooth were included as a further test of this phenomenon. Generally speaking, the darkest bones are the more worn and have the higher percentages of fluorine, i.e., the dolphin, kangaroo, and sharks' teeth. Some collectors have regarded the dark (unoxidized) bones as coming from below the nodule bed and the oxidized bones from the nodule bed or above. Auger holes 2 and 3 show that at the cliff the strata are oxidized for some feet below the nodule bed. However, the rocks at spring low-tide level and below are unoxidized and so the dark fossils probably come from there.

2. The wallaby and wombat are not so mineralized as the other fossil marsupials, and their fluorine indices are much lower. The wombat remains came from the beach between Cheltenham and Mordialloc, i.e., an area in which the younger Red Bluff member and not the Black Rock member outcrops. The index is what one might expect for a fossil from the younger member. The fossil wallaby came from the beach at "Cheltenham". It is only of more recent years that Beaumaris has become a village. Before that the whole area was called Cheltenham after the nearest railway station. Charman-road runs directly from the station to the beach, and where it meets the coast is where the monocline forms the boundary between the Black Rock member and the Red Bluff member. The fossil wallaby therefore could belong to the latter member, but even so its index is so low as to make one refrain from claiming a Tertiary age for it. The best thing to do is to put it in the category of the "not proven". At Wynyard, Hamilton, and Beaumaris, the Tertiary marsupials occur in similar environments, viz., shallow water marine beds, sometimes with wood and leaves suggesting the presence nearby of a river.

D. Australia's Tertiary Marsupial Fauna.

Professor R. A. Stirton's paper (1955) on Tertiary marsupials from Palankarinna, South Australia, appeared as this work was about to go to press, so the fossils described therein are now included with those referred to in this paper to constitute the list of Australian Tertiary marsupials so far discovered. Professor Stirton regards the fauna from Palankarinna as Pliocene because a notothere from there has affinities with the notothere from the Upper Miocene of Beaumaris, Victoria, but is evolutionally more advanced.

Site.	Age.	Facies.	Marsupial.	Taxonomy.
Palankarinna, South Australia	Pliocene ? ..	Fluviatile	Bandicoot ..	*Ischnodon australis* Stirton
,, ,,	,, ..	,,	Wallaby ..	*Prionotemnus palankarinnacus* Stirton
,, ,,	,, ..	,,	Notothere ..	*Meniscolophus mawsoni* Stirton
,, ,,	,, ..	,,	Koala	
Smeaton, Victoria ..	Pliocene or Pleistocene	,,	Between native cat and Tasmanian Devil	*Glaucodon ballaratensis* Stirton
Mentone Beach, Victoria	Pliocene ..	,,	Wombat ..	*Vombatus ?*
Grange Burn, near Hamilton, Victoria	Upper Pliocene	Terrestrial	Cuscus	
,, ,,	Lower Pliocene	Marine ..	Kangaroo	
Beaumaris, Victoria	Upper Miocene	,, ..	Notothere	
,, ,,	,,	,, ..	Giant kangaroo	
Wynyard, Tasmania	Oligocene or Upper Eocene	,, ..	Possum ..	*Wynyardia bassiana* Spencer

That all the giant Australian marsupials belonged to the Pleistocene was an idea previously accepted in Australia, but which must now be abandoned, as it is proved that nototheres and giant kangaroos were here in Tertiary time. Nor should this really occasion surprise because there were many giant placentals on other continents during the Tertiary.

The list of Australian Tertiary marsupials includes members of the following families:—

Diprotodontia	Phalangeridae.
	Phascolaretidae.
	Vombatidae.
	Macropodidae.
Polyprotodontia	Dasyuridae.
	Paramelidae.

This wide variety of forms suggests an early differentiation. The differentiation of the marsupials in Australia may well parallel the differentiation of the placentals on other continents.

The first glimpses of a stratigraphy based on the marsupials can be seen in this list. For example, the Upper Miocene notothere from Beaumaris is succeeded by the Pliocene notothere from Palankarinna, which in turn is succeeded by the Pleistocene *Nototherium* and *Diprotodon*.

It has been asked why more Tertiary marsupials have not been found in Australia. The answer may be that many deposits con-

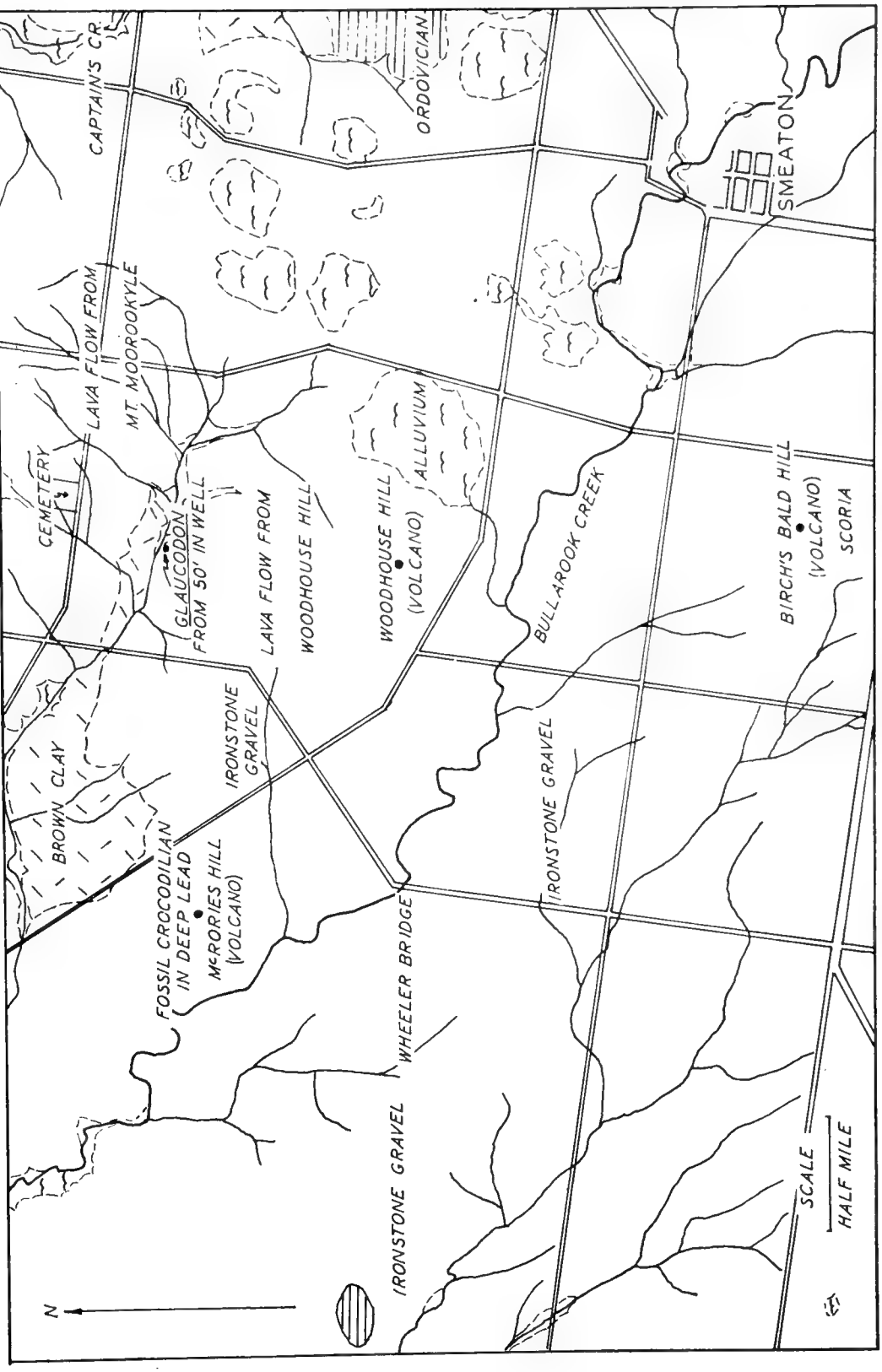
sidered Pleistocene because of the presence of giant marsupials or for other such inadequate reasons may be in fact Tertiary in age. Attention is now drawn to some such localities.

E. Some Possible Tertiary Marsupial Localities in Australia.

1. *One Tree Point, Tasmania.*—Johnston (1882), showed that the Derwent valley was occupied by a freshwater lake in Tertiary times. On pages 11 to 13 he gives an account of a section at One Tree Point, Hobart, where bone breccia was discovered in the joints of a lava flow. Johnston thought that this breccia was sealed off by another lava flow, and that it is therefore of the same age as the flows. Tasmanian geologists assign the basalts concerned an Upper Tertiary age. If Johnston's account of the occurrence of the breccia be correct, and if the basalts are correctly dated (there is no reason to doubt this), then the bones are of Tertiary age. Johnston recorded from the breccia a kangaroo-rat tooth determined as *Hypsiprymnus* (1882, figs. 63A-CC), and also " the well preserved incisor of an animal relating to the existing wombat." In an explanation of figures on page 50, there is listed a " fossil incisor of an animal probably allied to the existing *Halmaturus* from the bone breccia, One Tree Point." Figs. 65A-D comprise " various sections of a leg bone of a marsupial." On page ii. of the same volume, a donation is recorded from " Mr. J. Moore. Fragments of bone, teeth, &c., from a Tertiary deposit, exposed by blasting at the Alexandra Battery, One Tree Point." The figured specimens have not yet been located at the Tasmanian Museum, Hobart, but nineteen fragments from the same site numbered Z.164 have been found. Inside they are off-white in colour, with a light-brown (iron oxide) exterior surface. The fragments are ½ to 2 ins. long and ⅛ to 3/16 in. thick. They appear to be mostly fragments of a long bone or bones of a marsupial the size of a kangaroo. Johnston later (1888, pp. 280-281) published a section of the rocks at One Tree Point, and gave some further information about the fossil bones.

2. *Geilston Travertine, Tasmania.*—In the Papers and Proceedings of the Royal Society of Tasmania for 1881 there is a record (p. 12) of " bones obtained by the late Mr. Morton Allport from the Geilston Travertin." Johnston (1880B, 1885E, F) had already reported bones, fruit, leaves, and snails from this formation, which he regarded (1888) as Tertiary in age.

3. *Smeaton, Victoria.*—In an accompanying paper, Professor Stirton (1955B) has described a new genus and species of marsupial as *Glaucodon ballaratensis* (Ballarat being the nearest city) based on a ramus presented to this Museum by J. Marshall in 1914 (reg. No. P.16136). The fossil came from a depth of 50 feet in a well in section 42, Parish of Smeaton, which site is 2½ miles



TEXT-FIGURE 18.—Map showing the site of the well from which came *Glaucodon ballaratensis* Stirton. Based on the publications of the Geological Survey of Victoria.

north-west of the village of Smeaton, which is about 16 miles north of Ballarat, Victoria. The writer was conducted to the site by an old resident, J. V. Wilson, and by J. Keenan. As the sides of the well were tending to crumble (a commentary on the nature of the rock), a windmill was set up over the well, and the downpipe was protected with earthenware drain pipes. The space between the earthenware pipes and the sides of the well was then filled in with rock. It was thus not possible to study the walls of the well. However, the general geology of the area is as shown in Quarter Sheet 57 N.-E. and the geological map of the Creswick Gold Field published by the Geological Survey of Victoria. A map based on these is shown in text-fig. 18, on which the site is shown. An intensive study is needed before the fossil can be dated with accuracy, but the materials in which the well was sunk appear to have been laid down subsequently to the eruptions of the volcanoes represented by Mt. Moorookyle and McRorie's Hill. The site is older than Holocene, and is either Pleistocene or Pliocene. The Geological Survey mapped the formation as Upper Pliocene, but in those days (1880) the Pliocene-Pleistocene boundary had not been fixed.

4. *Buninyong, Victoria.*—At the Great Buninyong Eastate Mine at Buninyong, about 6 miles south of Ballarat, marsupial bones were found at a depth of 238 feet in a carbonaceous clay under the basalt. Details of the occurrence have been supplied by Hart (1899), and the bones found referred to *Macropus faunus* by De Vis (1899). Much argument has centered round a piece of a rib of a large marsupial (*?Nototherium*) thought to be a man-made tool (De Vis, 1899; Keble, 1945, 1947). The alleged implement is in the National Museum of Victoria, while the fossil bones are in the Museum of the Ballarat School of Mines. The writer does not consider the piece of rib an implement, and is undertaking fluorine and pollen analyses in an effort to determine the age of the deposit.

5. *Coimadai, Victoria.*—Lacustrine deposits originally considered to be Tertiary in age (Ferguson, 1894; Officer and Hogg, 1897, 1898; Dunn, 1910) were later considered to be definitely Pleistocene by Summers (1923), Coulson (1924), and Keble (1945) on the evidence of marsupial fossils determined by De Vis (in Officer and Hogg, 1898). Coulson also reports some rather indefinite plant remains. Marsupial fossils obtained from the limestone at Coimadai were determined by De Vis as:—

Phascolomys parvus Owen.
Macropus dryas De Vis.
M. anak Owen.
M. cooperi Owen.
Notothere remains.

Macroscopic plant remains in the National Museum from this site consist of *Casuarina* stems and fruits, which give no clear indication of age. A specimen of carbonaceous clay was analysed for pollen but proved negative. However, it is hoped that other investigations under way will be able to date the Coimadai deposit. Dating of this deposit will also date the Rowsley Fault and other important geological features.

There are many other localities with marsupial remains which may be Tertiary in age, and it is suggested that all the older beds containing such remains should be re-studied in the light of recent findings.

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EXPLANATION OF PLATES.

PLATE 1.

Reproduction of Professor Baldwin Spencer's original drawing of *Wynyardia bassiana*. Natural size.

FIG. 1. Dorsal surface of cranium.
FIG. 2. Ventral surface of cranium.
FIG. 3. Axis vertebra from the left side.
FIG. 4. Portion of the pelvic girdle showing the acetabulum and ischium.

PLATE 2.

FIG. 1. Coastal view looking west in the vicinity of Wynyard, north Tasmania. On the left is Fossil Bluff, whence came *Wynyardia*. In the distance is Table Cape which consists of basalt. In the foreground is the shore platform of Permian tillite.

FIG. 2. Fossil Bluff, consisting of Lower Tertiary sediments capped by basalt, and resting on Permian Tillite. The thin darker "*Crassatella* Bed" at the base of the cliff is succeeded by the much thicker "*Turritella* Bed."

FIG. 3. Looking down on the shore platform of Permian tillite, showing drop pebbles in a fine matrix.

PLATE 3.

FIG. 1. Forsyth's Bank on Grange Burn, near Hamilton, Victoria. The cliff consists of Grange Burn Coquina capped by basalt. In the foreground is the underlying Muddy Creek Marl, with remnants of the Nodule Bed on it. The ruins of Forsyth's house can be seen on the top of the cliff, and the motor-truck (top right) provides the scale.

FIG. 2. Bochara Limestone resting on the bedrock of quartz porphyry (left), Grange Burn, west of Henty's house and near the natural arch.

FIG. 3. Natural arch in Bochara Limestone on Grange Burn, west of Henty's house. The limestone is rich in lepidocycline foraminifera and other fossils.

PLATE 4.

FIG. 1. Stump of fossil conifer in fossil soil, covered by vesicular basalt, on south bank of Grange Burn at locality 10 (see text-figure 3), west of Hamilton, Victoria. Scale given by rule, of which a little over 5 ins. is showing.

FIG. 2. Locality 10, Grange Burn, near Hamilton. The fossil *Cuscus* tooth came from the fossil soil under the basalt. The figure in the photo is 5 ft. 4 ins. high.

FIG. 3. Ferruginized sediments of the Grange Burn Coquina in crevices in quartz porphyry country rock at locality 9, Grange Burn (see text-figure 3).

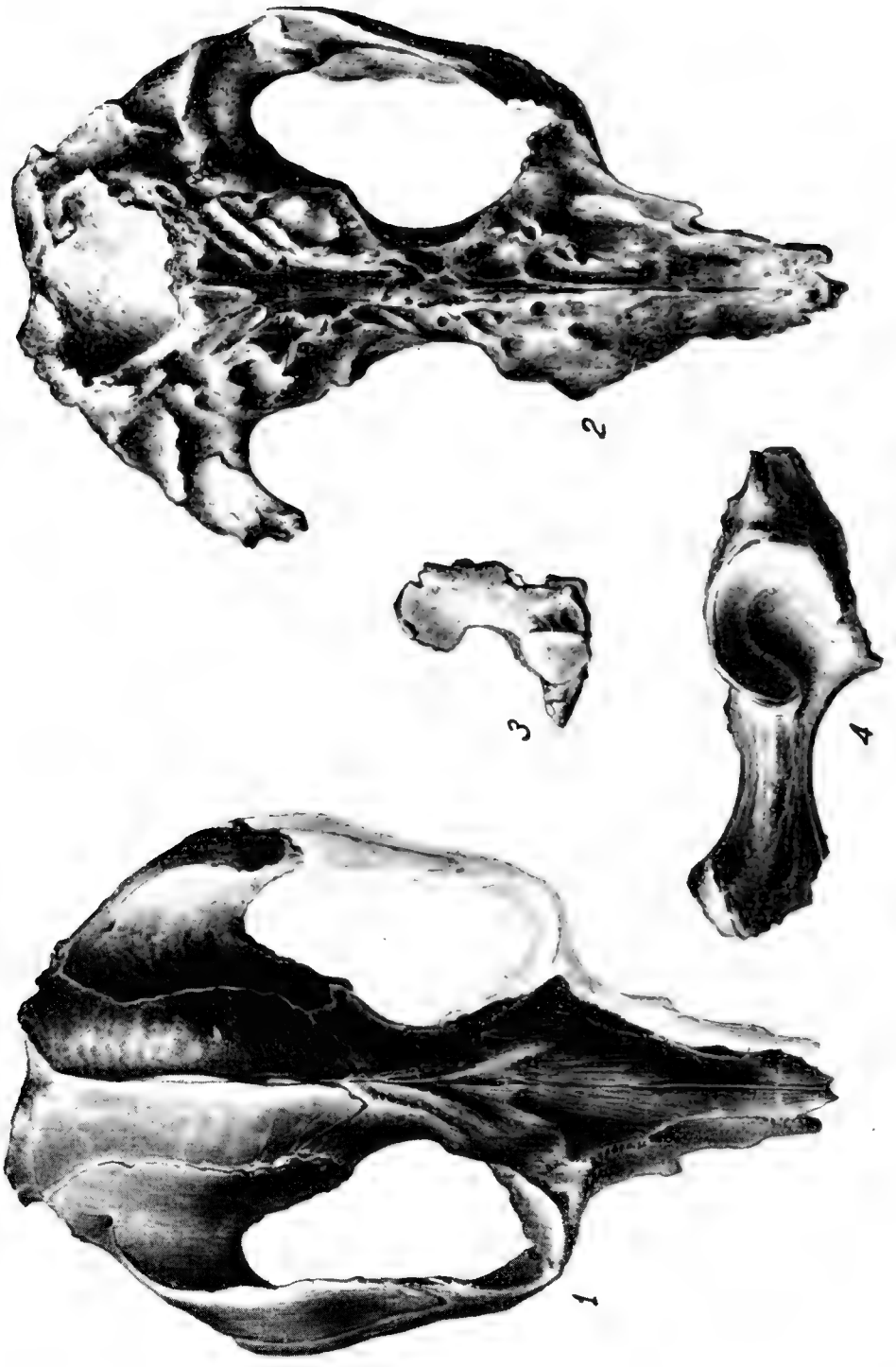


PLATE 1.

PLATE 2.

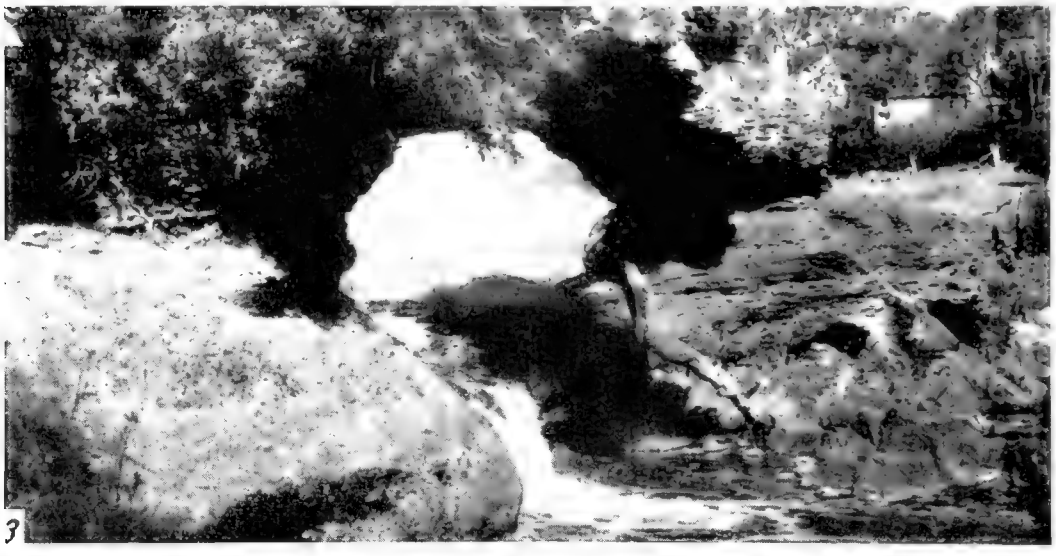
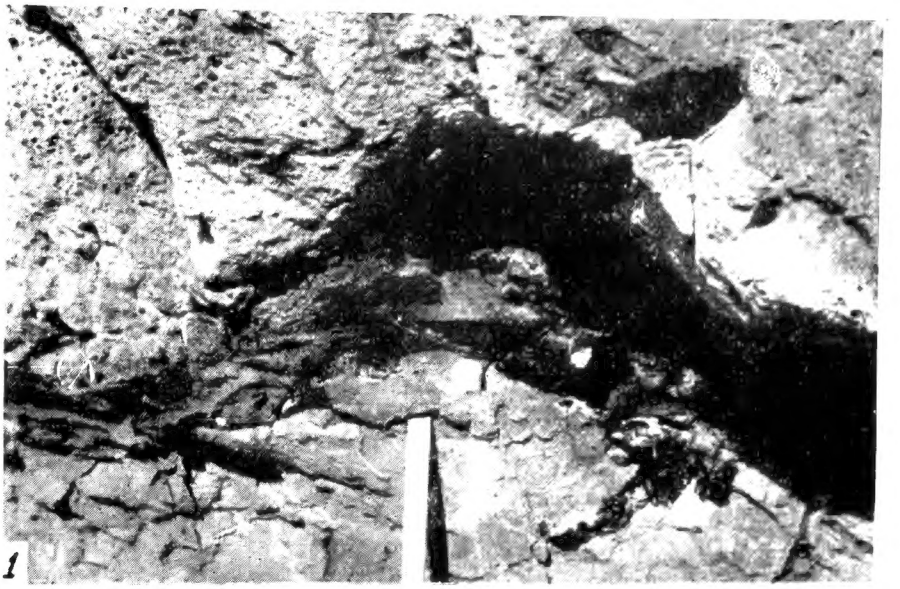


PLATE 3.



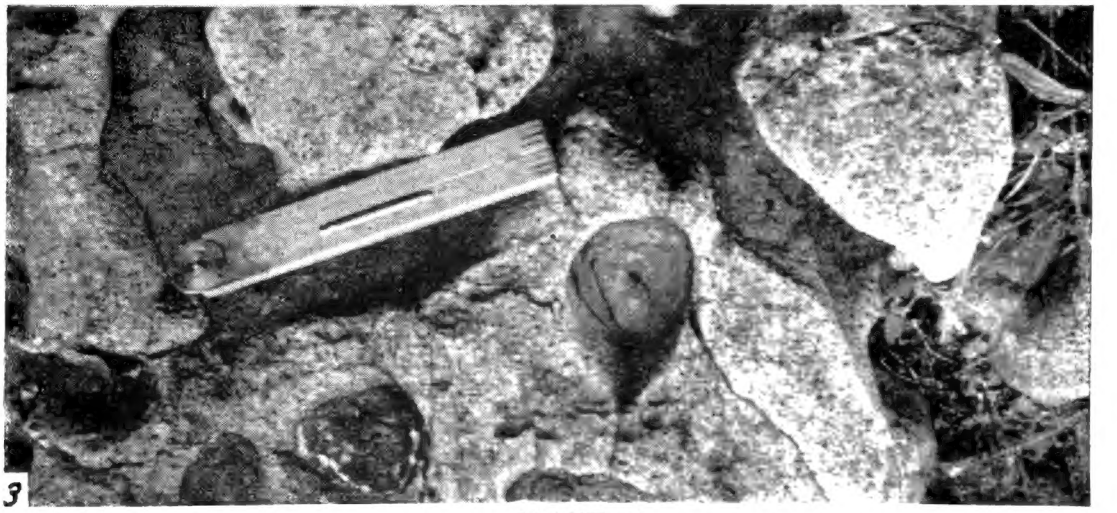


PLATE 4.

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